WOODBURN PORT-OF-ENTRY AUTOMATION PROJECT

1986 - 1993

Final Report

Oregon Experimental
Feature Project #OR 86-01

by

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16. Abstract

In 1986, the Oregon State Highway Division (OSHD), in conjunction with the Public Utility Commission (PUC), and with the cooperation of the Federal Highway Administration (FHWA), undertook an experimental project at the Woodburn southbound Port-of-Entry (POE). The plan was to automate this POE to minimize the weighmaster and PUC tasks; improve weight, size,and safety enforcement; provide more data for planning and design purposes; and save human resources and time for the State and the trucking industry. The weigh-in-motion (WIM) scale, automatic vehicle identification (AVI) system, and static scales, along with the PUC motor carrier database would be tied into a supervisory computer system which would control truck traffic and data.

This report presents findings from five years of operations and describes the construction and automation of the Woodburn POE, including the physical plant, the hardware and software, system operation, data obtained, benefits, limitations, conclusions and recommendations.

This project is a success, even though all the theoretical benefits were not achieved, because only a few trucks carried transponders. Enough actual benefits exist to consider this experiment a success. These benefits include improved weight and safety enforcement, data collection access, human resources savings, weighmaster productivity gains, vehicle screening, capital expenditure savings, and increased trade productivity. The monetary benefits greatly exceed the automation costs.

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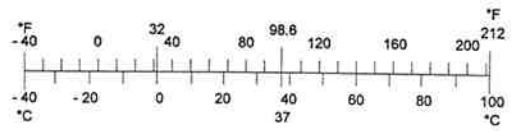
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

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1 The Oregon Department of Transportation was reorganized in 1992. The names of many units have been changed; for example, the Planning Section has become the Transportation Development Branch.

2 Retired

3 Entered private industry

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DISCLAIMER

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1.0 INTRODUCTION

In 1986, the Oregon State Highway Division[1] (OSHD), in conjunction with the Oregon Public Utility Commission (PUC), and with the cooperation of the Federal Highway Administration (FHWA), undertook an experimental project at the Woodburn southbound Port-of-Entry (POE). The plan was to automate this POE to minimize the weighmaster and PUC tasks; improve weight, size, and safety enforcement; provide more data for planning and design purposes; and save human resources and time for the State and the trucking industry. The weigh-in-motion (WIM) scale, automatic vehicle identification (AVI) system, and static scales, along with the PUC motor carrier database were to be tied into a supervisory computer system which helped to control truck traffic and data.

1.1 PURPOSE OF REPORT

The purpose of this report is to present findings from five years of operations and to describe the construction and automation of the Woodburn POE. This report describes the physical plant, the hardware and software, system operation, data obtained, benefits, limitations, conclusions, and recommendations.

1.2 HISTORICAL BACKGROUND

1.2.1 POE CONCEPT

The POE concept was developed in 1984 as reported by Krukar and Evert (*1, 2*). The POE's were to be jointly operated by Oregon Department of Transportation (ODOT) weighmaster(s) and the Public Utility Commissioner (now Commission), providing a single location where all services relating to motor carriers entering the state are available - the "one-stop shopping" concept. This broad coverage increases the probability that most truck drivers are in compliance with all the size/weight, safety, and motor carrier tax laws of the State.

The first POE was built in Ashland alongside the I-5 northbound lanes in 1975. The Farewell Bend POE alongside I-84 westbound was added in 1977, Klamath Falls POE alongside the US-97 northbound lanes in 1979, Woodburn POE alongside the I-5 southbound lanes in 1986, and Cascade Locks POE alongside the I-84 eastbound lanes

[1] In 1992, the Oregon Department of Transportation (ODOT) reorganization eliminated all divisions, including the Highway Division; OSHD is now ODOT.

in late 1989. Umatilla POE alongside the I-82 southbound lanes and US-395/730 westbound lanes became fully operational in 1993.

The POE concept has evolved over the years from separate quarters and buildings for both the weighmaster(s) and the PUC personnel at Ashland to joint quarters in one building at Farewell Bend and elsewhere. The Woodburn POE was the first POE to have an all-weather truck inspection building. New and existing POE's will have these inspection buildings.

1.2.2 WIM INTEGRATION WITH AVI IDENTIFICATION SORTING CONCEPT

The idea of sorting vehicles using weigh-in-motion (WIM) scales came from the First National Weigh-in-Motion Conference held in Denver, 1983. At this conference, the idea of using automatic vehicle identification (AVI) systems tied with WIM was introduced by Henion (*3*). This idea was developed and tested successfully in Oregon during 1984-85 as reported by Krukar (*4*).

The first medium-speed (20-40 mph [32-64 kph]) WIM system was installed and tested at the Woodburn weigh station in 1984 located on I-5 northbound. The success of this system as reported by Krukar (*4*) led to the installation of a similar sorter system at the Woodburn POE and then at the Cascade Locks POE. Similar sorting systems are and will be installed at the other POE's in the future.

This concept has evolved to one of sorting heavy vehicles at highway speeds before entering the POE. The concept is being demonstrated at the Umatilla POE, and with two prototype systems at the two weigh stations located near Roseburg on I-5 southbound at Wilbur and on I-5 northbound at Booth Ranch.

1.2.3 THE AUTOMATION CONCEPT

The success of this WIM/AVI demonstration project led the personnel of the Weighmaster(s) Unit[2] and Economic Services Unit, Planning Section[3], to further expand the concept to one of complete automation of a POE, integrating WIM, AVI, static scales, and motor carrier database. The purpose being to reduce weighmaster

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[2] Now the Automation and Weighing Facilities Unit, Motor Carrier Services Section, Driver and Motor Vehicle Services Branch.

[3] Now the Research and New Technology Unit, Policy and Research Section, Transportation Development Branch.

tasks, reduce truck drivers' time at POE, and automate the data collection and flow. Steering and Technical Advisory Committees were formed to develop the concepts and ideas. These concepts, ideas, benefits, and costs were reported in a white paper written by Krukar (*5*). The Technical Advisory Committee helped develop the Request for Proposals (*6*) and choose the consultant.

1.2.4 WOODBURN SOUTHBOUND SITE

The Woodburn southbound POE was chosen as the site for this experimental project. The reasons were that this POE was being constructed, everything was new, and the WIM/AVI and other equipment could be incorporated into the ongoing construction, thus minimizing costs. The FHWA agreed to fund the POE including the WIM system with 4R funds (92% FHWA, 8% State Match) and fund 33% of the AVI, automation hardware, and software (State Match 67%). The concept developed into the Woodburn southbound POE Experimental Project.

1.3 THE NEED FOR A WOODBURN POE

Interstate Highway 5, which starts at the California-Mexico border and ends at the Washington-Canada border, is the principal north-south highway in the Pacific Northwest. It is Oregon's principal heavy vehicle commercial route. Yet for many years, there was no POE alongside the I-5 southbound lanes, south of the Washington State border. There was, and still is, a Public Utility Commission (PUC) office by the Jantzen Beach Interchange at Mile Point 308 where trucks entering Oregon from Washington could obtain permits. There was no weigh station alongside the I-5 southbound lanes until Mile Point 274.2 which was not open twenty-four hours a day. No PUC transactions were handled at this station.

In the early 1980's, both the weighmaster(s) and PUC realized that the existing weigh stations had the following inadequacies: 1) exit and entrance ramps were too short for safety; 2) not enough parking capacity for vehicles; 3) inadequate facilities for weighing present volumes of heavy vehicles; 4) no facilities for safety inspections; and 5) inadequate facilities for the "one-stop shopping" concept.

The present day heavy vehicle enforcement has evolved from monitoring heavy vehicles carrying Oregon's basic commodities such as timber and agricultural products to one of service to help the truck drivers stay within Oregon's laws. The evolution of enforcement strategies has been reported by Krukar and Evert (*1,2*). This service concept has evolved into the "one-stop shopping" where the facilities are built to weigh heavy vehicles, provide PUC services, and conduct truck safety inspections. PUC and weighmaster(s) are under one roof and there is a truck inspection building with bays. Delays are minimized as much as possible. Before the Woodburn southbound POE was built, the three existing POE's did not entirely meet the "one-stop shopping" concept. The weighmaster(s) and PUC considered

combining weight and size enforcement, PUC permits, and truck safety inspection at one location.

In late 1983, the ODOT started a WIM and automatic vehicle identification (AVI) demonstration project, testing a medium speed WIM sorter with AVI systems at the Woodburn northbound weigh station and a high speed WIM data collection system with AVI on I-5 northbound at Jefferson. In late 1984, based on the initial success of the WIM/AVI Demonstration Project, the idea of combining WIM/AVI with the static scale, and installing a supervisory computer (SC) with appropriate software to monitor, store, modify, and transfer weight data was discussed.

1.4 WOODBURN SOUTHBOUND POE

The Woodburn POE is located alongside the I-5 southbound lanes at Mile Point 274.40. The Woodburn POE has one WIM sorter system and two electronic static scales. The latter are located by the weighmaster and PUC offices. A truck inspection building is also on the premises off to the west side. Figure 1 shows an aerial view of the POE.

The Woodburn POE is the busiest POE in the State. All POE's are operated 24 hours a day and seven days a week. A minimum of 2,000 trucks pass through the facility during a 24-hour period. During peak periods, over 4,000 trucks per day pass through the POE. During a peak hour, 150 to 250 trucks may pass through the Woodburn southbound POE.

The plan was to automate this POE to minimize the weighmaster and PUC tasks, resulting in improved weight, size, and safety enforcement, more data for planning and designing purposes, and manpower and time savings to the State and the trucking industry.

1.5 POE FUNCTIONS

The purpose of a POE is to monitor and regulate trucks using the state highways with respect to truck weight, size, safety, and weight-distance taxation. These various functions are divided or shared between the weighmaster(s) and the PUC.

The purposes of the weighmaster(s) are to: 1) protect the Oregon highways from overloaded and oversized trucks; 2) monitor truck safety; and 3) oversee the transportation of hazardous materials. Their functions are tied to their purposes. Weighmaster(s) functions are to weigh trucks to ensure that they are legal with respect to gross, axle, and tandem weights, height, width, and length, and comply with the bridge formula. Weighmaster(s) have statutory authority to control weight, size, and safety, and cite motorists for violations. They, along with PUC, monitor trucks for safety and the transportation of hazardous materials. The weight information is used by PUC for weight-distance tax audits.

The PUC has both regulatory and tax collection functions. The Motor Carrier Services Section's functions at POE's are to collect weight-distance taxes from those vehicles who are not already registered, ensure authority compliance, enforce truck equipment safety standards, and monitor the transport of hazardous materials. The latter two functions are shared with weighmaster(s) although PUC has statutory responsibility and control.

At present, it takes a weighmaster 20 to 40 seconds to weigh a truck at a static scale, depending upon the truck type. More time is needed if the truck is found to be in violation. The weighmaster manually records the truck identification, commodity, classification, number of axles, gross weight, and axle weights. Thirteen manual tasks are required to complete the above procedure. This information is sent to the PUC Motor Carrier Services Section, where it is manually key-punched into the PUC mainframe computer. This information is used for tax audit purposes.

About 85 percent of the trucks passing through the static scales already have the PUC papers and are not in violation of the weight limits. The remaining 15 percent are either cited for some kind of weight violation, or need an extended weight permit or a PUC permit for weight registration or both. These trucks will have to go to the legalizing loop and park. The truck driver will have to make a stop which may vary from 5 to 25 minutes or longer depending if his truck load is overweight and has to be adjusted or removed. Extra time is needed by the weighmaster to write violations.

1.6 THE NEED FOR AUTOMATION

Present technology offers the opportunity to improve efficiency at Oregon's POE's. POE's are presently labor intensive for the weighmaster(s), using 60 percent of the available field crews. Automating the system means long-term increases in productivity resulting in reduced human resource requirements, better data collection, more efficient truck weight, size and safety enforcement, improved weight-mile tax collection and audits, and time savings to POE users.

1.7 AUTOMATED POE FUNCTIONS

An automatic system at the Woodburn POE will allow the trucks (assuming all trucks have transponders) to bypass the static scales and the PUC office. Eighty-five percent of the trucks will be able to take advantage of this, minimizing their productivity losses. A truck with a transponder will have its identification number read by the AVI reader, and will be weighed by the WIM. This data will be transmitted to the SC and stored for future transfer to the ODOT mainframe computer. The SC will have data on 250,000 vehicles which will include information as to whether any given PUC plate is suspended, or for some other

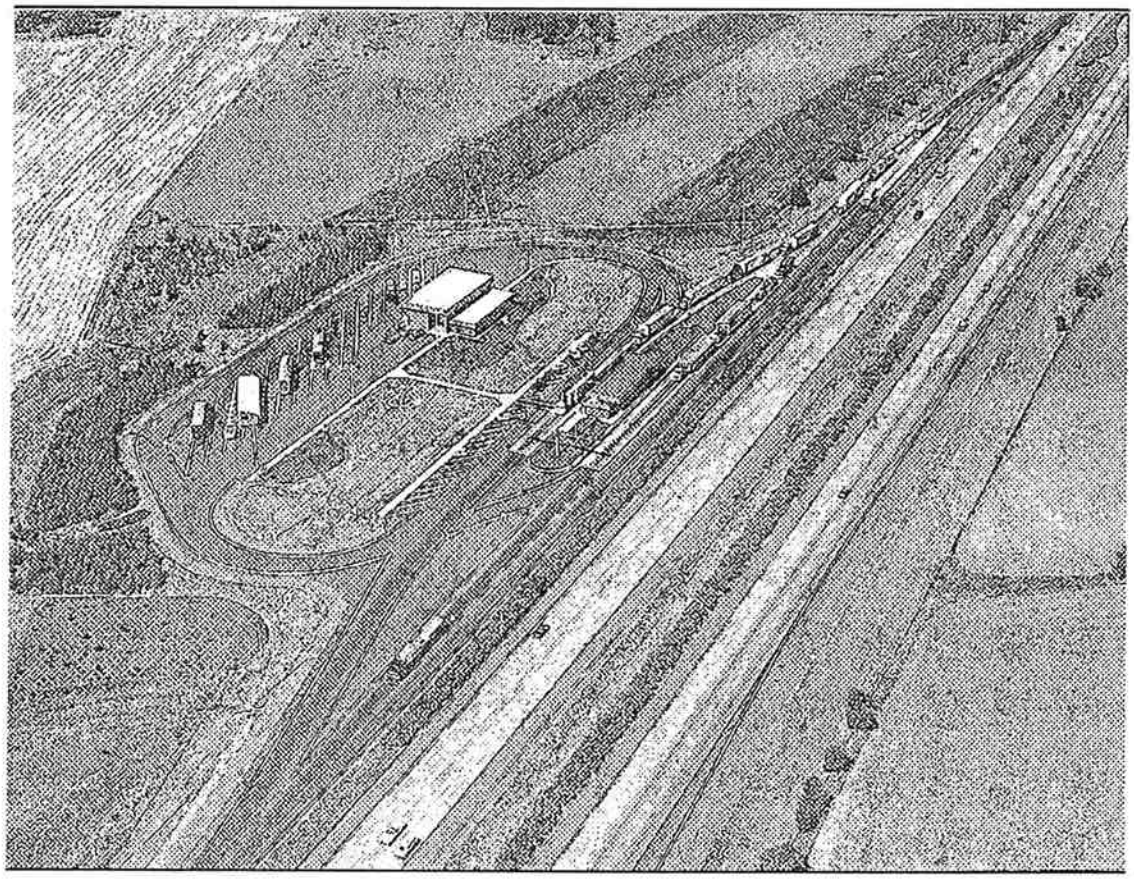

Figure 1.1: Aerial View of Woodburn Southbound POE

reason invalid. This will allow the weighmaster to take immediate action in case of suspended plates; in the past, this information was not readily available to provide timely action at the POE. The SC will also have name and address files on 40,000 carriers. In addition, the SC will also have a "chronic offenders" list allowing the weighmaster(s) to automatically check if the truck meets both the weight and legal registration conditions. If the truck meets both the weight limits and registration requirements, then it will automatically be permitted to bypass both the static scales and the PUC office, thus minimizing time losses.

The "chronic offender" plate file list is a list of truck drivers and trucking firms that continually violate weight, size and safety laws. The information on repeat weight, size, and safety offenders will be collected from citation files supplied by the weighmaster. The PUC Safety Division will provide additional information associated with safety violations. At this time, the weighmaster(s) do not have an official "chronic offender" list, but individual weighmaster districts keep informal tabs on "chronic offenders" in their area. This list will be current, official, and will start immediately. The weighmaster(s) will use this list to try to

get additional sanctions on the individual truck drivers and trucking firms. Trucking firms that are in continual violation will be visited by weighmaster(s) and warned about their performance. The PUC will provide information about "chronic offenders". This list will enable the weighmaster(s) and PUC to identify violators immediately. The use of this list should enhance weight, size, and safety enforcement.

If the WIM shows that the truck does not meet gross or axle weight limits and/or bridge formula, and oversize criteria, and the SC shows that it meets PUC requirements, and/or safety inspection validation, and is not on the "chronic offender" list, then the truck will have to only go to the static scales to be weighed. If in violation, it will be ticketed. If the WIM shows that the weights are legal, but the SC shows that PUC registration requirements have not been met, then the truck may bypass the static scales but still has to go to the PUC office to obtain the necessary papers. If the truck violates both the legal weight limits and/or size limits, and PUC requirements, then the truck will have to go to both the static scales and the PUC office. This automated system should reduce the number of vehicles going to the static scales to 15 percent of the total traffic. All WIM data will be stored and telemetered daily. The WIM data on trucks that are allowed to bypass the static scales will be transferred and stored on the SC.

Extended weight permits will also be in the SC files. The weighmaster(s) will be able to tell if a truck has an extended weight permit and if it does, allow it to bypass the scales.

The linking of the Weightronix static scales to the SC will allow the automatic recording and storing of the static weights. The weighmaster will directly feed the truck identification (PUC number) with the data commodity number into the SC. This automated system will improve weighmaster productivity by reducing the present 13 manual tasks to four. The PUC will save on key-punch operator's time and key-punching errors and every truck will be checked against the SC information.

Safety inspection information will also be in the SC files. Weighmaster(s) will be able to tell when a truck was inspected. If it has not been recently inspected, they will be able to send the truck to the safety inspection bay.

This static weight information, along with the WIM information on trucks bypassing the static scales, will be stored and transferred to the ODOT mainframe computer. The SC will also provide the weighmaster Supervisor a daily summary of the number and types of vehicles weighed at the static scales and number of violations by type. The PUC will be able to update the vehicles files to the SC on an hourly basis.

The combination of AVI, SC, and WIM will permit trucks to completely bypass the static scales and the PUC office provided they meet both PUC and weight requirements. AVI and SC alone will not permit trucks to bypass the PUC station, only the static scale. Therefore, an AVI, SC and WIM system is needed to make this POE automation demonstration work properly.

In 1988, only 400 trucks of the total truck population had transponders. Based on the AVI experience at the Woodburn northbound weigh station, about 100 trucks with transponders will pass through the Woodburn POE daily. This limited system will demonstrate the feasibility of the fully automated POE. This small sample should not affect the linkage of the Weightronix static scales with the SC, and should demonstrate even more forcefully the improved productivity of the weighmaster(s).

The Heavy-Vehicle Electronic License Plate (HELP) or the Crescent Study Demonstration Project currently underway will provide information on what AVI technology is superior. These test will take about two years. In 1990, there was enough information for the State to decide which AVI system it will adopt and what kind of transponders will be issued to all trucks. It is possible that the present AVI system and transponders currently in use may not be the system of the future. The goal is that before the end of the century, all trucks in Oregon will be carrying transponders which will make this POE truly automated.

2.0 POE PHYSICAL PLANT

2.1 SPECIFICATIONS

Five different specifications were developed for this project. A set of specifications was written for: 1) the POE; 2) the WIM sorter and approach slab; 3) the variable message sign; 4) the AVI; and 5) the POE automation.

2.1.1 PORT-OF-ENTRY

The expansion of the existing weigh station to a POE required acquisition of additional land and the moving of existing power line towers onto private land. Five acres of abutting farm land was acquired for the additional facilities needed for this POE.

Bonneville Power Administration staff moved the towers. Plans and specifications were developed by Final Design Section staff of ODOT[4]. The design of this POE was unique because this was the first time that ODOT had designed a heavy-vehicle inspection bay into a POE design. The overall result was successful, but some omissions occurred.

The project went out for bids in September, 1984. Ross Brothers was the successful bidder at 2.2 million dollars. The project was to be completed by November, 1985, but it was not completed until January 15, 1986, when the POE became operational.

2.1.2 WIM SORTER

The specifications were written by Weighmaster Unit staff. The plans were essentially modifications of the plans developed for the Woodburn northbound weigh station. The reinforced portland cement concrete (PCC) slab was lengthened to 250 feet [76 m], including a 150 foot [46 m] approach to the WIM sorter and 100 feet [30 m] after the WIM sorter.

The specifications called for a WIM sorter with an overweight detector, directional signal lights, various induction loops, approach slab, and installation. General Services requested the bids. CMI-Dynamics was the successful bidder at $200,000.

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[4] Now part of the Technical Services Branch of ODOT.

The WIM sorter system includes the WIM-4 computer that stores the WIM data from the WIM scales. Software has been developed and installed for processing the WIM data. The AVI system is interfaced with the WIM-4 which receives and matches the AVI data with the appropriate WIM data this data is then sent to the SC system. The WIM-4 also controls the bypass signals.

2.1.3 VARIABLE MESSAGE SIGN

The specifications for the variable message sign were developed by Weighmaster(s) Unit staff and General Services handled the bidding process. Lake Technologies was the successful bidder at $50,000.

2.1.4 AUTOMATIC VEHICLE IDENTIFICATION

The same system that is being used at the Ashland POE, Jefferson, Woodburn northbound weigh station, and Ridgefield POE, was installed at this POE. General Railway Signal supplied the equipment and also installed it. The WIM/AVI software interface was developed by ADEC through CMI-Dynamics.

2.1.5 POE AUTOMATION

The specifications for the automation were developed by Planning Section staff through the Steering and Technical Advisory Committees. This included the hardware for the SC System and all the necessary interface software. The request for proposals was sent out in May 1986 and bids were received in July 1986. An evaluation committee evaluated the proposals and made a recommendation. Motorola Computer Systems was selected to be the consultant, at a bid of $130,000. Table 2.1 shows the actual costs.

2.2 CONSTRUCTION AND INSTALLATION

Problems on the whole were minimal and most of the work went smoothly.

TABLE 2.1 The Costs for the Woodburn POE and WIM/AVI/Automation

Item	Cost - $
POE: land, construction, buildings and additions	2,300,000
WIM/AVI (Includes WIM-4 computer)	200,000
WIM/AVI/SC Communications Software Interface	10,000
SC and Accessory Electronics Hardware	55,000
SC Software (custom/database)	45,000
Functional Specification	12,000
Variable Upgrade #1	30,000
Variable Upgrade #2	10,000
Variable Message Signs	50,000
TOTAL	2,712,000

2.2.1 POE FACILITIES

The construction start was delayed by the contractor due to other job commitments. No major problems occurred. The high water table posed some temporary problems. The inclement weather also caused some delays. The result was that the POE was opened in January, 1986 instead of November, 1985 as specified. As mentioned in Section 1.0, the approach slab, WIM/AVI and variable message sign, although part of the POE physical plant, were separate from the main project.

2.2.2 PHYSICAL PLANT

Figure 1.1 shows the overall layout of the POE. There is a deceleration lane, a bypass lane, an exit lane, two electronic static scales and platforms, a parking lot for heavy vehicles, a WIM/PUC office building, and a truck inspection building with adjoining offices.

2.2.3 POE OFFICES

Both weighmaster(s) and PUC functions are housed in a one-story building as shown in Figure 2.1. The building consists, going north to south, of an observation room from which the PUC plates can be identified, a computer room, weighmaster offices facing each side, and PUC offices.

No major problems occurred. Some additional conduit and rewiring was needed for the automation equipment. Some minor refinishing was required.

2.2.4 TRUCK INSPECTION BAY BUILDINGS

These buildings are located on the west side of the site as shown in Figure 1.1. The truck inspection building, shown in Figure 2.2 consist of a one story office building which consists of a classroom, showers, toilet and lunch facilities, lockers, and an administration office. The inspection bay building is 80 feet long and consists of two inspection bays, one with a pit and the other with floor lights. These are shown in Figures 2.3 and 2.4, respectively. Two heavy vehicles can be inspected simultaneously.

There were no problems with the construction of the buildings. This was the first truck inspection building built by ODOT and some design problems occurred due to lack of experience. They included:

1. The length of the inspection bay building. Triple combinations are 105 feet [32 m] in length and cannot fit the 80-foot [24 m] long building. New truck inspection buildings are being designed to 120 feet [37 m] lengths like the Cascade Locks, and Umatilla POE's. The Woodburn POE inspection bay has been lengthened to 120 feet [37 m].

2. The bay doors. These could only open and close electrically and had no manual controls. This could be a hazard and a manual system was installed.

3. The guardrail installed by the side of the inspection bay pit to prevent trucks from accidentally falling into the pit. It was found that the guardrails and their installation were inadequate, were easily knocked over, and therefore dangerous. This was finally solved by using channel irons and bolting them down. This is shown in Figure 2.3.

4. The truck exit from the inspection pit did not have enough straight-away. The truck drivers start turning their trucks almost immediately to exit and their rear wheels hit the guardrail. The exit could not be lengthened but the use of the heavier and stronger channel iron as guardrail solved the problem.

5. There were no physical barriers between the two truck inspection bays, thus causing a potential safety hazard. This was solved by installing storage counters as shown in Figures 2.3 and 2.4.

6. The floor lighting for the floor inspection bay. The plans were obtained from California which has been using this system for over 10 years. Our state building inspectors found that it was not UL approved and did not meet safety standards. This has been resolved with minor modifications to the existing system.

7. The inspection building was unheated and it can get cold during the winter. A radiant heating system has been installed.

2.2.5 INSPECTION PIT VERSUS LIGHTED FLOOR

Both types of vehicle inspection systems are used at the Woodburn Truck Inspection Bay. There are advantages and disadvantages to both systems.

The advantages of the inspection pit are:

1. all vehicles can be inspected, even the low ones;

2. all personnel can participate, even those who cannot crawl under a vehicle and

3. to some weighmaster(s), their perception is that the pit is a cleaner and safer place to work.

The disadvantages to the pit are that it requires heavy safety guardrail to prevent one of the wheels from falling into the pit, and the pit needs special ventilation to prevent carbon monoxide and flammable fumes build-up.

The advantages of a lighted floor are that the underside of the heavy vehicles are fully lighted, thus making inspection easier.

The disadvantages of a lighted floor are:

1. some vehicles are so low that the inspector cannot crawl under;

2. some inspectors are physically unable to crawl under a vehicle;

3. the perception by some weighmaster(s) is that crawling under a vehicle is dirtier than using an inspection pit; and

4. a lighted floor system requires a special cooling system to prevent heat build-up.

Both systems work well and complement each other. Both systems should be put in all future truck inspection bays.

2.3 ELECTRONIC STATIC SCALES

2.3.1 PLATFORM SCALES

Two static scales with load cells and electronic digital readout were obtained from A-1 Scale of Portland. Each scale has four load cells. Ross Brothers installed the scales, built the 14 by 16 foot [4 by 5 m] scale decks, and the scale approaches. Figure 2.5 shows the west static scale.

Some problems occurred with the approaches. On the east side, the approach slab is uneven, thus puddles formed during wet weather. This causes inconvenience to the weighmaster(s) if they have to go outside to talk with the truck driver. A solution would be to grind down some of the high spots.

There was another problem with the scale approach on the west side, discovered when truck drivers complained that the scale readings were higher than at other scales. No fault could be found with the scale itself. Examination of the scale approach revealed that it was lower than the scale. This would induce dynamic effects, thus affecting the truck weights. The problem was solved by installing steel plates in the wheel paths of the approach pavement as shown in Figure 2.5. This problem of scale installation and approaches will continue in the future at other weigh station sites unless people recognize that the installation and fitting of scales is highly specialized work. Persons installing scales travel from job to job doing nothing else. Although the contractor did a fairly good job with the static scales, mistakes were made. In the future, it might be worthwhile to insist that the prime contractor subcontract this work out to a specialist.

2.3.2 SMALLER PLATFORM SCALES VERSUS LARGER PLATFORMS

Some state are using larger platforms and also sectional scales. These sectional scales are theoretically able to weigh the whole vehicle in parts. The steering axle, drive axles, and trailer axles are weighed and linked together to get gross weight. Oregon has preferred the small platform scales. What are the relative advantages between these scales?

The weighmaster(s) prefer the smaller platform scale, based on experience, because

1. smaller scales are more cost effective and maintenance free

Figure 2.1: View of the POE 1 Offices

Figure 2.2: View of Truck Inspection Bay Building and Offices

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Figure 2.3: View of Truck Inspection Pit (Note the side channel beams)

Figure 2.4: View of Floor Inspection Bay with Floor Lights and Skate Board

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2. the many types of vehicles (e.g., the 105-foot [32 m] triple trailer) in Oregon necessitate the use of smaller scales. The most common sectional platforms are 70 feet [21 m] long. A platform scale 105 feet [32 m] long is needed to weigh a triple;

3. these longer sectional scales require too much maintenace;

4. sectional scales can measure axle weights and are linked together to give gross weights. However, the large variance in axle placement can cause problems with these scales. For example, the predominant heavy vehicle in Oregon is the 5-axle semi-trailer, 3S2. About 50 percent of these vehicles make up truck traffic, but there is a large variety and divergence in these types of vehicles. Other types of vehicles in Oregon have 5 to 9 axles. There is an industry trend, because of national and Oregon weight laws, to change the 3S2s to 4S3s. This will change the axle placement and make sectional platforms less effective; and

5. there are no time savings in using sectional scales for weighing. The shorter scales are just as fast and just as accurate.

2.4 WIM SORTER SYSTEM

2.4.1 WIM SCALES

The scale, manufactured and installed by CMI-Dynamics, was similar to the one installed at the Woodburn northbound weigh station. The only difference was that the scale surface plate was longer than the one at the weigh station, covering more area and leaving less space between the wheel paths. The scale is shown in Figures 2.6, 2.7, and 2.9 along with axle sensor and induction loops.

The installation of the scale in the vault went smoothly. The vault design was based on the one used for Woodburn northbound weigh station. No problems were encountered installing the scale frames and the scales. The vault was built when the reinforcing steel was installed for the PCC approach slab.

2.4.2 AXLE SENSOR

The axle sensor is part of the WIM system and measures axles. This is needed for a sorter since the vehicle is decelerating, thus affecting the induction loops. The axle sensor is shown in Figures 2.6, 2.8, and 2.9.

No problems occurred with the installation of the sensor frame and the sensor. The problem was with the sensor electronics. The sensor failed to work properly twice, once due to faulty wiring and the second occurrence due to a faulty water proofing seal. Both times the sensor was replaced with a new one. The third one was working fine until November 1988, when fatigue cracks appeared. A new type of axle sensor called Dynex was installed.

2.4.3 OVERHEIGHT DETECTOR

The installation of the overheight detector went smoothly. Figures 2.7 through 2.9 show different sides of the detector.

2.4.4 DIRECTIONAL SIGNALS

The directional signals were installed 260 feet [79 m] from the WIM scale. These signals are 30 feet [9 m] farther away than the Woodburn northbound weigh station and allow more time for the truck drivers to react. Induction loops were installed to record vehicle position and to trigger the directional signals. Figures 2.9 and 2.10 show these signals.

2.4.5 WIM ELECTRONICS

The WIM computer and other electronics were placed in an equipment cabinet. This cabinet is shown in Figure 2.7. The cabinet has two doors, one for the "hot" electrical wires and connections and the other for electronic equipment. This cabinet has plenty of room. No downtime has been lost due to heat build-up which occurred at the Jefferson site.

Two CRT monitors were installed in the weighmaster side of the POE offices, one by each of the static scales so that the weighmaster(s) could view the WIM weighing. The weights from WIM and static scales can be compared at a glance.

2.4.6 THE PCC WIM APPROACH SLAB

A 250 foot [76 m] long PCC slab was placed near the entrance to the POE. The slab was to have a zero percent grade and maximum smoothness. The WIM vault was set 150 feet [46 m] south of the slab approach edge, thus allowing 100 feet [30 m] of exit pavement. An expansion joint was installed north of the WIM scales.

Figure 2.5: View of West Static Deck and Approach Slab with Leveling Steel Plates AVI Activator

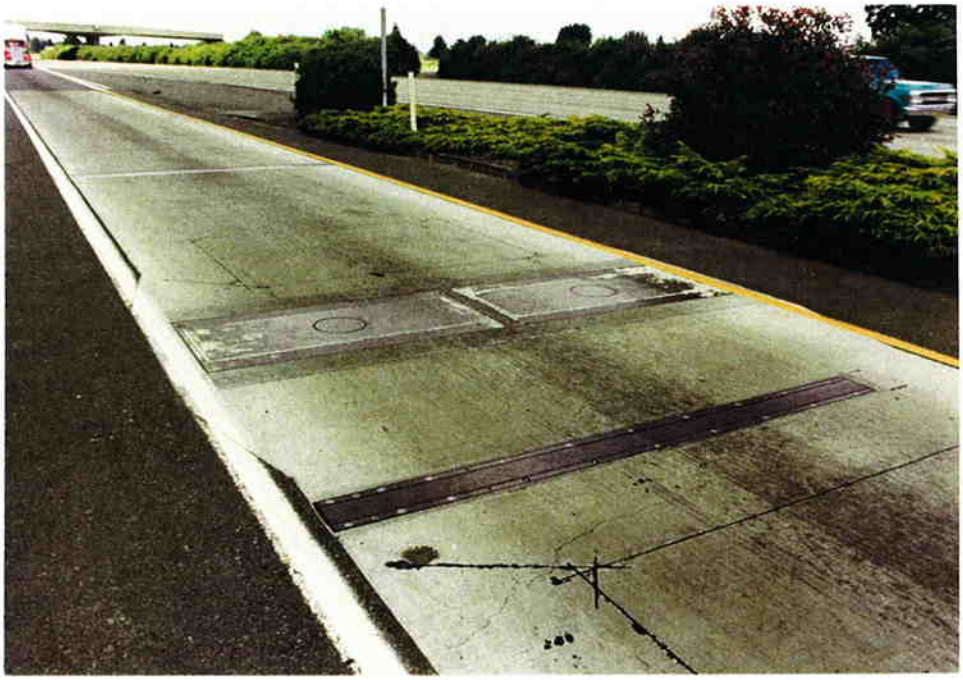

Figure 2.6: View of Axle Sensor, WIM Scales, Induction Loops and PCC Approach Slab

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Figure 2.7: Looking South, View of WIM Electronic Cabinet, Overheight Detector, and AVI Activator

Figure 2.8: Looking South, View of WIM, Approach Slab, and Overheight Detector (Note Expansion Joint in Foreground)

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Figure 2.9: Looking South, View of Approach Slab, WIM, and Overheight Detector (Note Directional Signals in Background)

Figure 2.10: View of Directional Signals (Note Variable Message Signs)

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Figures 2.6, 2.8, and 2.9 show the approach slab. The purpose of the slab was to minimize the dynamic effects of pavement surface and vehicles on WIM weight measurements.

The slab was designed by ODOT staff and is basically the standard bridge approach slab design. A similar slab was used at the Woodburn northbound weigh station except that the total length was 200 feet [61 m]. Because of interference problems on the induction loops due to the heavy steel, the reinforcing steel bar diameter was reduced to the next size.

Several problems were noted over time. One, the pavement surface was not as smooth as the slab at Woodburn northbound weigh station. A greater effort needs to be made to minimize the pavement roughness to reduce vehicle dynamic effects. Two, the south side of the slab developed surface poxmarks. This usually is a sign of dirty aggregate causing poor adhesion, and thus popping out of the pavement. The PCC plant needs to wash their aggregate. Three, the asphalt concrete pavement abutted the PCC slab, and over time, ruts and shoving of asphalt concrete occurred. This caused a bump inducing dynamic loads on the pavements. This could have been minimized by developing a keyed or transition zone leading to the slab. It should not be an abrupt edge. Another solution would be to extend the PCC slab to the highway. Four, the approach slab length of 150 feet [46 m] to the WIM is too short. In theory, at least 300 feet [91 m] of smooth slab is needed to dampen vehicle and pavement effects and at least 125 feet [38 m] of smooth slab is needed past the WIM. In the future, where a sorter WIM is installed, an attempt should be made to have over 400 feet [122 m] of smooth pavement.

2.4.7 VARIABLE MESSAGE SIGN

The variable message sign, provided by Lake Technologies, never lived up to expectations. This sign was a prototype model and as such, had some sensor design problems. One, the sign was too slow and it could not flash complex messages to the truck drivers fast enough. Two, during bad weather, the signal changes became sluggish. Three, when one light bulb went out, so did all the others. This was corrected but the other problems were not overcome. The company went out of business so technical problems had to be solved by ODOT staff.

2.5 LESSONS FROM WOODBURN

The lessons learned from the Woodburn POE design problems have been incorporated into the new Cascade Locks POE, into the proposed Umatilla POE, and retrofitting of the other POE's.

The approach slab to the WIM has been lengthened. PCC pavement is being used to minimize rutting and maintenance. The new variable signs have been computerized and speeded up. The housing has been modified and the inspection bay building has been lengthened. There have been other minor changes.

The first prototype design always has some problems. One needs to learn from them and make sure that they are not repeated. Overall, the Woodburn POE had few major problems. This is a tribute to the ODOT designers.

3.0 THEORETICAL ASPECTS OF AUTOMATION

3.1 PURPOSE OF AUTOMATION

The purpose of automating the AVI, SC, and WIM at one POE was to show that POE's can be automated so that the ODOT and PUC can benefit from human resource savings and improved enforcement of truck size/weight limits and safety, and allow truck drivers to save time. Some of these aspects have been described in a white paper by Krukar (*5*) and further described at the Third National Weigh-in-Motion Conference by Krukar and Evert (*7*).

3.2 AUTOMATION

3.2.1 COMPONENTS

The automation of the Woodburn southbound POE consists of six elements which are:

1. the WIM sorter;
2. the AVI system;
3. the electronic static scales;
4. the motor carrier database;
5. the SC; and
6. the various software interfaces.

3.2.2 THE NEED FOR AUTOMATION

This was described in Section 1.7 of this report.

3.3 POTENTIAL BENEFITS FROM AUTOMATION

Both the State and the trucking industry should benefit from such a system. These benefits will occur if the system is fully automated and all vehicles carry transponders. Both the weighmaster(s) and PUC will benefit from improved productivity. The State will benefit

from improved weight and safety enforcement. Various ODOT sections will benefit from improved data collection. The trucking industry will benefit through time savings which minimize productivity losses at the POE.

3.3.1 ASSUMPTION ONE

All trucks will have transponders before the end of the century.

3.3.1.1 Weighmaster Benefits

Monetary Benefits:
This POE will be the busiest in the state, handling 2,000 or more trucks per day with a peak of 150 to 250 trucks per hour. With a fully automated system, this number will be reduced by 85 percent to 300 trucks daily. This will reduce weighmaster POE human resource requirements by about 30 percent. The POE is staffed 24-hours a day, requiring two persons per shift. During the weekend, only one person is required per shift. Automation offers the potential to reduce the POE staff from 13 to 9. This will free four weighmaster(s) for other assignments, such as enhancement of the weight enforcement program.

Estimated yearly savings are:
$1,730/month x 12 months + 32 percent benefits x 4 people = $109,613

Productivity Gains:
The reduction of 13 manual tasks to 4 will increase the weighmaster(s)' productivity by reducing fatigue and stress. The SC will allow the weighmaster to spot potential violators immediately. All this should improve weight enforcement.

In addition, the files in the SC will let the weighmaster know if the truck was recently inspected for safety. If not, the truck can be identified and sent for inspection at the bay. All this should result in improved safety and benefit the public.

The weighmaster(s) will also benefit from having summary tables automatically prepared by the computer. In the past, this was done manually. This should free some of the POE supervisor's time for other duties. These tables will allow for more effective uses of the available personnel through scheduling.

3.3.1.2 PUC BENEFITS

Monetary Benefits (Human Resource Benefits):
The truck data will be automatically stored in the SC from the WIM and static scales. It will be transferred to the PUC mainframe on a daily basis. In the past, the manually written information from the weighmaster had to be keypunched into the mainframe by an operator. This will eliminate this step and save personnel for other uses, such as safety inspections or increased weight enforcement duties on the other highways.

The potential monetary savings per year at this POE are:
16 hours/week x 52 weeks x $12.00/hr. = $10,000

Additional Truck Weight Taxes:
The automated system at this POE should increase the collection of truck weight taxes through improved truck weight information. PUC estimates this to be annually: $11,500.

Productivity Gains:
Productivity gains will come from more efficient truck weight information and thus, improved tax audits. Automation will eliminate the keypunch errors made by PUC operators. The data should be more reliable, thus helping with tax audits. The PUC will have the ability to update their vehicle and "safety inspection" files on an hourly basis and thus, keep information current. All this should result in more efficient truck weight tax collection.

3.3.1.3 ODOT Data Collection

Various ODOT sections will benefit from improved truck weight data. Data from the WIM and the static scales will be available for planning, pavement design, research, traffic engineering, and cost responsibility. In the past, this data was available, but had to be processed manually. Now, it will be available immediately on a daily and weekly basis.

3.3.1.4 Improved Weight Enforcement/Tax Collection

The WIM information will help the weighmaster(s) with bridge formula violations. The "chronic offender" list should allow the weighmaster to spot repeat offenders. The

vehicle file allows the weighmaster to see if the vehicle has all the necessary registration and permits. The result will be a more efficient weight enforcement.

The freeing of some weighmaster(s) at the POE will allow for scheduling human resources for additional weigh station operations on other highways. This will increase the number of weighings on these routes, thus enhancing weight and size enforcement, including tax collection.

In the past, truck traffic at peak volumes frequently backed up at weigh stations, causing bottlenecks and safety hazards. The only solution was to let trucks bypass the scales until the truck volumes were reduced. Now, with WIM, all trucks can be weighed safely during peak traffic volumes even if they are allowed to bypass the static scales since a record of their weight is available. This helps with weight enforcement.

In addition, this will allow PUC to collect taxes more rapidly. The SC will allow the weighmaster(s) to spot trucking firms that are behind in their tax payments and send them over to the PUC office for collection on the spot.

3.3.1.5 Improved Safety Enforcement

The vehicle safety files will contain information on truck safety inspections. This will enable the weighmaster to know if the truck's safety inspection is current and whether the carrier has a high or low safety profile. Thus, this system can improve and increase truck vehicle safety inspections.

3.3.1.6 Truck Productivity

The automated POE will allow 85 percent of the trucks to bypass the static scales and PUC offices. This will minimize time losses. Time savings will be on the order of 60 seconds per vehicle. This will result in savings in operating costs. This will amount annually to:

60 seconds x $1.00 per minute operating costs
x 85% (2,000 daily truck average) x 365 days = $620,500

The improved enforcement of weight limits and safety will help the legitimate trucking firms improve their competitive situation by reducing illegal or unethical operations.

3.3.1.7 Monetary Benefits, Assumption One

Total annual monetary benefits to the State are:

Weighmaster Savings	$109,613
PUC Savings	$ 10,000
Improved Tax Collection	$ 11,500
TOTAL	**$131,113**

3.3.2 ASSUMPTION TWO

400 trucks with transponders for this feasibility study.

3.3.2.1 Weighmaster Benefits

Monetary Benefits:
These will be marginal at best, since this will reduce the number of trucks by perhaps 100 per day during a 5-day week. No reduction in manpower is anticipated.

Productivity Gains:
These are similar to those mentioned under Assumption One.

3.2.2.2 PUC BENEFITS

Monetary Benefits (Manpower Benefits):
These are similar as under Assumption One. The annual monetary savings are estimated to be $10,000.

Additional Truck Weight Taxes:
The same amount of additional taxes will be collected annually as under Assumption One. This is conservatively estimated to be $11,500.

Productivity Gains:
These will be similar to those obtained under Assumption One.

3.3.2.3 ODOT Data Collection, Improved Weight Enforcement, Tax Collection, and Improved Safety Enforcement

Similar benefits are expected as under Assumption One.

3.3.2.4 Truck Productivity

Since only 400 trucks will have transponders, truck productivity gains will be small.

It is estimated that 100 trucks with transponders will pass through the Woodburn southbound POE on a daily basis, five days a week. Time savings will be about 60 seconds per vehicle. The potential monetary savings per year are:

60 seconds x $1.00 per minute operating costs
x 600 trucks per week x 52 weeks = $31,200

3.3.2.5 Monetary Benefits Assumption Two

Total annual monetary benefits to the State are:

Weighmaster Savings	$ 0
PUC Savings	$ 10,000
Improved Tax Collection	$ 11,500
Total	$ 21,500

3.3.3 Pay Back Period

Costs of Automation of POE:

WIM	$200,000
AVI	$ 24,000
Automation	$100,000
Total	$404,000

Total Annual Pay Back; Assumption One	$131,000
Total Annual Pay Back; Assumption Two	$ 22,000

Pay-back period = $404,000 ÷ $131,000 = 3.1 years
Pay-back period = $404,000 ÷ $22,000 = 18.4 years

It should be noted that this would be a temporary situation. If this demonstration is successful, and the HELP Project results are positive, all trucks may have transponders in the future.

3.4 HOW THE SYSTEM WILL OPERATE

3.4.1 OPERATION OF SYSTEM

Figure 3.1 shows the overall layout of equipment in the POE. This system is designed for measuring weights at truck speeds of 20 to 40 mph [32-64 kph]. At any time, the system can be manually overridden by the weighmaster(s).

The following points describe the events as a vehicle equipped with a transponder passes through the system:

1. The vehicle trips loop 1 (located several feet upstream from the WIM scale). This causes the computer (WIM-4) to begin accepting data from the AVI reader.

2. The vehicle's axles pass over the WIM platform, the axle sensor, and the overheight detector.

3. The AVI reader activates the vehicle's transponder (assuming General Roadway Signals system) and transmits the vehicle ID to the WIM-4.

4. The vehicle leaves loop 2 (located several feet downstream from the WIM scale).

5. The WIM-4 calculates the axle spacings, single axle, tandem axle, gross weights, bridge formula compliance, height, and determines (using the "standard" sorting algorithm) whether the vehicle should be directed to the "Report" or "Bypass" lanes.

6. The WIM-4 transmits a "vehicle packet" to the SC computer. Among other things, this packet contains the axle weights and spacings, the vehicle ID, and the current sorting threshold.

7. The SC computer looks up the vehicle ID[5] and determines the direction the vehicle should take based on permits for extended weight.

8. The SC computer sends back an "override packet" to the WIM-4. This packet contains the information on the route the vehicle should take and the size of the worst three axle group overloads if such overloads exist.

---

[5]It should be noted that the transponder ID code may not be the same at the PUC truck ID number. This means that a translation table will have to be set up to match the transponder ID number with the proper PUC truck ID numbers for PUC use. About 150 transponders will have correct PUC numbers in this initial phase; the remaining 250 transponders will have different numbers.

9. The vehicle trips loop 3 (located 140 feet [43 m] and 110 feet [36 m] downstream from loop 2 and the directional signal lights, respectively), and the WIM-4 activates the appropriate signal in S1 (signal lights for the "report" and "Bypass" lanes).

10. Operation continues for any other vehicle.

    (a) If the vehicle obtains the "bypass" lane signal, it will continue on lane 1 until it triggers loop 4 (located approximately 175 feet [53 m] downstream from the directional signal lights). This activates a signal at the weighmaster station, telling him whether this vehicle is legal or not. Weight and ID information from the WIM-4 are automatically transferred and stored in the SC. If the vehicle is in the wrong lane, an alarm alerts the weighmaster to change the variable message sign to notify the truck driver to go to the legal loop, and return to get weighed.

    (b) If the vehicle obtains the "report" signal[6], it will continue in either lanes 2 or 3 triggering loops 5 or 6, respectively. (These loops are located 300 feet [91 m] downstream from the directional signal lights and 300 feet [91 m] upstream from the static scales). These loops will determine which CRT screens are to be activated by that vehicle.

11. (a) As the vehicle approaches the Weightronix static scales in lanes 2 or 3, the weighmaster will keypunch the PUC plate number into the SC. The SC will flash on the CRT screen whether or not this vehicle is on the "chronic offender" list and meets both PUC and weighmaster regulations and permits.

    (b) The weighmaster will also automatically have WIM information from the WIM-4 computer on the vehicle as it enters either lane 2 or 3. The weighmaster can have four screen options on the CRT from the WIM-4. These are:

        Option A: Vehicles and weights in lanes 2 and 3.
        Option B: Vehicles in the bypass lane (lane 1).
        Option C: in option A and B and shows weight broken down into wheel loads and balance of load for each wheel.

---

[6]If the truck is traveling too slow (less than 20 mph), or traveling too fast (over 40 mph) on the WIM scales, the truck will also be given the "report" signal besides for the obvious reasons for being weight and size illegal, or not having the proper plates.

Option D: Data Collection Tables.

(1) Cumulative vehicle tables - 7 days information.

(2) Number of vehicles by speed, axles, vehicle lengths and vehicle classification.

12. As the vehicle is weighed on the static scale, the axle weights and bridge formula data are recorded and the gross weight automatically calculated. These are shown on the CRT screen and are entered via the "enter" button to the SC and stored for later transmission to the mainframe.

13. (a) If the vehicle is weight and size legal and has met all the PUC and weighmaster requirements, the weighmaster will manually activate the variable message sign for the vehicle to go back to the freeway.

    (b) If the vehicle is weight illegal, and/or size illegal, and/or does not meet PUC or weighmaster regulations, then the weighmaster will manually activate the variable message sign for the vehicle to go to the parking lot, park, and ask the driver to see the weighmaster and/or the PUC personnel.

14. As the vehicle passes through the Weightronic static scales, it will trigger either loops 7 or 8 (located approximately 28 feet downstream from the static scales) in lanes 2 and 3, respectively. These loops will automatically scroll off the vehicle on the CRT screen.

15. Operation continues for any other vehicles.

16. Hourly, the accumulated data on vehicles with transponders weighed by the WIM and vehicles weighed on the static scales in the SC will be transmitted to the ODOT mainframe computer via the appropriate file transfer software and computer to computer communications. Updated vehicle data from PUC will be downloaded to the SC.

17. The SC will also give the weighmaster(s) a daily summary list on:

    (a) Number of vehicles weighed by class type, commodity, and weights obtained from the static scales during the 24-hour period.

    (b) Number of violations by axle, tandem, group of axles, combination or vehicles, oversize, and non-weight related.

    (c) Number of vehicles weighed by the hour during a 24-hour period.

(d) Violation percentage by each of the totals, and total violations.

(e) Historical statistics - by month, quarter, and year.

(f) Number of vehicles weighed during the 24-hour period and by hour basis by the WIM scales.

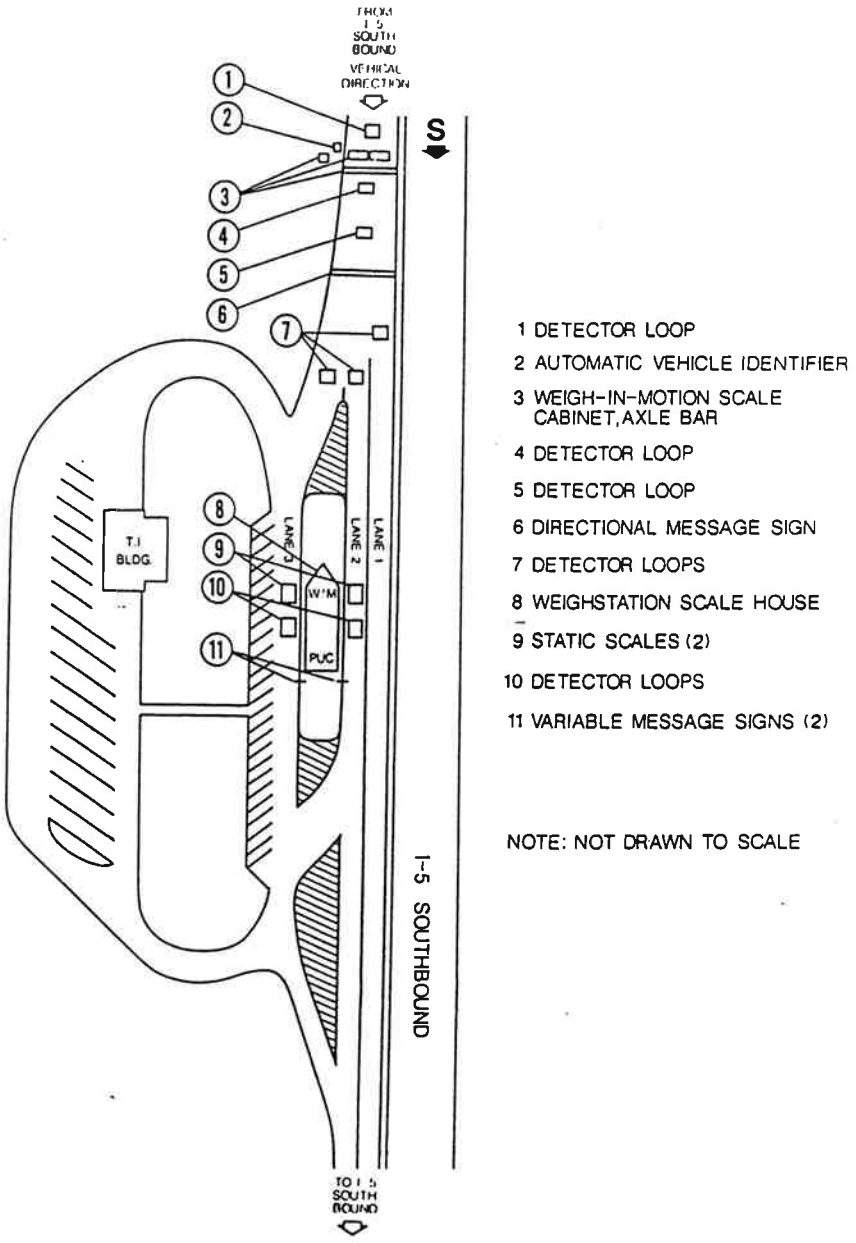

Figure 3.1: Woodburn Southbound POE Equipment.

3.4.2 IMPORTANT ASPECTS

Some of the important aspects of this system are outlined below:

1. The WIM-4 works independently of the SC. If the SC is out of service, all sorting is based on the "standard" sorting algorithm.

2. The vehicle reader's antenna must be positioned so that the reader-activator does not send anything to the WIM-4 until the vehicle trips loop 1 and has sent the complete vehicle ID by the time the vehicle leaves loop 2. The minimum time is 200 milliseconds of a second between loops at 45 mph.

3. The override packet must be received by the WIM-4 before the vehicle trips loop 3, otherwise the WIM will sort on the "standard" algorithm. This places quite tight time constraints on the SC computer. For example:

   - Assume 120 feet [37 m] between the trailing edge of loop 2 and the leading edge of loop 3.

   - Example vehicle has 7 axles, is 80 feet [24 m] long and is traveling at 40 miles per hour [64 kph]. This results in about 680 milliseconds between the rear of the vehicle leaving loop 2 and the front of the vehicle entering loop 3.

   - The vehicle packet from the WIM-4 would be about 78 bytes which would take 150 milliseconds to transmit to the SC (assuming a 4800 baud link between the machines).

   - The override packet from the SC would be about 18 bytes which would take about 4 milliseconds to transmit to the WIM-4.

   - The SC has about 500 milliseconds to loop up the vehicle's identification and to determine whether the vehicle should be directed to the static scale. The present system accomplishes this in approximately 140 milliseconds.

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4.0 RESULTS FROM AUTOMATION

4.1 AUTOMATION COMPONENTS

4.1.1 EQUIPMENT AND SOFTWARE

Table 4.1 shows all the automation components used by the weighmaster(s). The SC, is a Motorola 8400E model with a 161 MB hard disk, a 68020 processor, a 60 MB streaming tape backup, a 8 MB DRAM, and three CRTs. The two printers were from IBM.

The relational database software, supplied by Motorola, was developed by Informix. The mainframe communications and relational database was developed by Motorola using a 4th generation language for customware programming.

4.1.2 POE CONFIGURATION

The configuration of the different components is shown in Figure 4.1. Note that PUC has almost a duplicate system in their area of the building. Their use is different from the weighmaster(s) since they use it for word processing, spreadsheets, and other miscellaneous applications. In case of any kind of breakdown, either the weighmaster(s) or PUC can switch to the other system without any loss of time or data. The systems are not redundant in that each has its own distinct uses. One computer system could run both operations but there would be time delays, problems with sending data to the host computer and also receiving updated PUC information. The functions for the weighmaster(s) are different from PUC and there is a need for two systems.

4.2 SUPERVISORY SYSTEM APPLICATIONS OVERVIEW

The applications of the functions have been developed by Rytter (*8*) in Motorola's Functional Specifications.

4.2.1 WEIGH STATION PARAMETERS APPLICATION

This application sets up weigh station application program parameters of:

Inspection Date Threshold - The weighmaster(s) are able to instruct the SC to signal any vehicle which has not had a safety inspection within "x" days to report to the static scale.

Updated Program Interval - The weighmaster(s) are able to set the frequency of execution, in minutes, of the unattended program which processes database updates from the host, and schedules PUC Weight Reports and citation images for transmission to the host.

Statistics Collection Time - The weighmaster(s) are able to set the time of day that the unattended time-triggered monthly statistics collection program will execute. This program is executed once daily to extract data from previous days statistics for monthly report statistics.

TABLE 4.1 Equipment and Software Used in POE Automation

Type	Manufacturer	Model	Amount
WIM	CMI-Dynamics	SS 200--IDC(R)	1
AVI Transponders	General Railway Signal		350
Reader-Activator	General Railway Signal		1
Antennas	General Railway Signal		1
Static Scales			
Readout	Weightronix	WW110	2
Load Cells	Mastron		2
Deck	Contractor		2
Supervisory Computer			
Computer	Motorola	8400 E, 161 MB Hard Disk	1
Processor	Motorola	68020	1
Streaming Tape	Motorola	60 MB	1
D.R.A.M.	Motorola	8 MB	1
CRTs	Motorola	TM 228	3
Printers	IBM	4224	2
Software			
Relational Database Software	Informix	Informix SQL	1
Mainframe Communications	Motorola	SNA 3270/3770	1
Rational Database Custom Software	Informix/Motorola[1]	4th Generation Language for Customware Programming	1

[1] Motorola is no longer in the business of supplying this type of software.

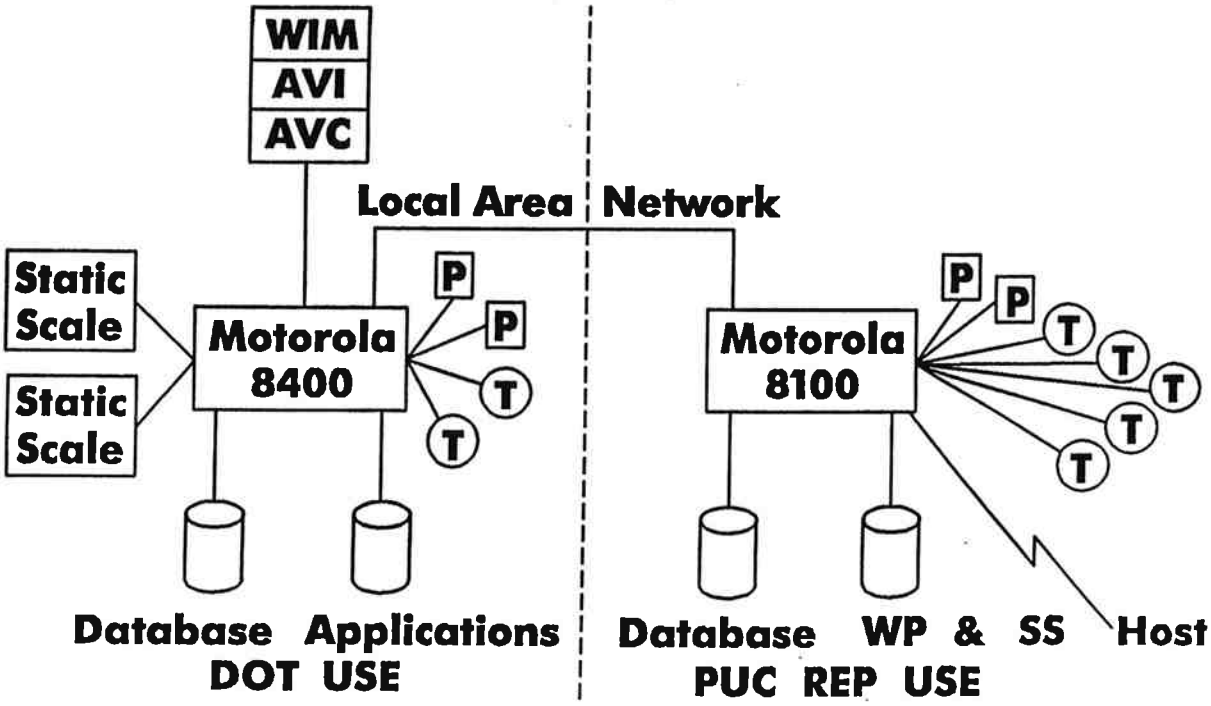

Figure 4.1: POE Configuration.

4.2.2 WEIGHMASTER APPLICATIONS

WIM Interface - This application executes as an unattended program providing the interface between the Motorola equipment and the CMI-Dearborn WIM/AVI equipment for the real time sorting of vehicles.

Static Scale Weighing - This application executes the main application used by the weighmaster. The application accepts information from the weighmaster, loop up and display PUC and other data from the database, and reads weight data from the Weightronix static scale.

Citation Writing - This application is used to input violation information and print a citation on a preprinted form. The image of the citation is also prepared for transmission to the host.

PUC Plate Number Assignment - This application is used to update the temporary vehicle identification number, assigned by the weighmaster and saved in the Supervisory System vehicle statistics when an unregistered vehicle reports for a static weighing, with the plate number being assigned by the local PUC representative.

Chronic Offender Review - This application is used to confirm the assignment of Chronic Offender status to a carrier.

Citation Modification - The prime function of this application is the notation on previously written citations of load legalizations through off loading or loading shifting. This application is used to modify and reprint citations, to modify only the database copy of the citation, or to delete citations from the database. An audit trail of citations which have been changed is maintained for management report purposes. An image of the modified citation, or a record identifying the deleted citation, is prepared for transmission to the host.

Vehicle Statistics Modification - This application is used to modify or delete vehicle statistics which would be reported in the PUC daily Weight Report. An audit trail identifying weigh statistics records which have been changed or deleted is maintained for management report purposes.

4.2.3 REPORT GENERATION

PUC Daily Report - This application is used to produce a printed copy, and/or file for transmission to the host, of the PUC Daily Weight Report; the weighmaster(s) are able to specify the starting and ending periods for which the report is to be produced.

Daily Summary Reports - This application is used to produce a printed copy of the:

(a) Daily Operation Summary

(b) Average Gross Weight by Hour Summary

(c) Vehicle Class by Hour Summary

(d) Commodity by Hour Summary

(e) Citations by Hour Summary

Monthly/Quarterly Triples Activity Report - This application is used to produce a month-to-date or quarter-to-date report identifying the vehicles with triple trailers which have passed through the weigh station.

Monthly/Quarterly Operation Summary Report - This application is used to produce a month-to-date or quarter-to-date Weigh Station Operation Summary Report.

Monthly/Quarterly Statistics Modification Report - This application is used to produce a month-to-date or quarter-to-date report identifying vehicle weigh statistics which were modified or deleted from the database.

Monthly/Quarterly Citation Modification Report - This application is used to produce a month-to-date or quarter-to-date report identifying citations which had been written and then modified or deleted from the database.

Monthly/Quarterly Productivity Progress Summary - This application is used to produce a month-to-date or quarter-to-date summary by employee number identifying weigh station production during the hours that the employee worked.

Monthly/Quarterly Chronic Offender Report - This application is used to create a month-to-date or quarter-to-date report identifying carriers which have been assigned Chronic Offender status during the selected period. Optionally, a report identifying all carriers noted as Chronic Offenders can be created.

In addition, normal WIM reports can be obtained on truck weighings, types, weights by the day and week. This is obtained directly from the WIM computer.

4.2.4 APPLICATION PROGRAM SELECTION

The application system was developed as a set of hierarchial menus which guide the weighmaster to the entry point of the application to be executed. The menu tree is shown in Table 4.2.

4.2.5 HOST COMMUNICATIONS

File Transfers - File transfer capability, uses 3770 emulation, for updating the PUC NAME and PLATE records in the Supervisory System database and for transferring the PUC Daily Weight Reports and citation images to the host will be provided. This is done every 180 minutes.

Host Inquiry - This application allows 3270 terminal emulation for host inquiry operations.

4.2.6 SYSTEM MAINTENANCE

Record Maintenance Application - This application is used to delete from the database those records maintained by the SC as the source for weight reports, daily, monthly, and quarterly summaries, when they are considered to be of no further historical value.

Database Backup and Restore - Utility programs for tape backup and database restoration is provided through UNIX-executable scripts.

System Files Restore - When the System was installed, a complete copy of system-level software was provided for purposes of restoring a "crashed" system. This function is executed only by Motorola support personnel.

Initial Database Record Load - A UNIX-executable script has been provided for executing the utility program to load the initial PUC NAME and PLATE record database from tape.

4.3 USER ACCEPTANCE OF SYSTEM

The system was enthusiastically accepted by the weighmaster(s) and supervisors. The reasons were:

1. The POE weighmaster(s) were frequently guests of the Technical Advisory Committee and were asked to give their input;

2. the Motorola programmers worked closely with the weighmaster(s) in developing the customized software and screen projections;

3. the weighmaster manual functions were reduced from 13 to 4; and

4. the supervisors were able to generate reports via the system at will.

Everybody benefited. The weighmaster(s) were part of the process and their output and suggestions were frequently adopted. Everything was geared to their level and not to the supervisor's level. Therefore, acceptance was universal. In fact, the weighmaster(s) at other POE's complained that they were neglected and demanded similar systems.

TABLE 4.2 Hierarchial Menus Used in Application System

MAIN MENU
Supervisory weighmaster Applications Menu
Weighmaster Applications Menu
Report Generation Applications Menu
Record Maintenance Application
Weigh Station Parameters Application

SUPERVISORY WEIGHMASTER APPLICATIONS MENU
Configure Weigh Station Application Parameters
Configure Weigh Station System Parameters
Configure User Application Access Privileges
Start WIM Interface
Terminate WIM Interface
Display Shared Memory

WEIGHMASTER APPLICATIONS MENU
Static Scale Weight
Citation Writing
PUC Plate Number Assignment
Chronic Offender Review
Citation Modification
Vehicle Statistics Modification
Vehicle Statistics Display and Print

REPORT GENERATION APPLICATIONS MENU
Daily Reports
PUC Daily Weight Report
Daily Summary Reports
Temporary Plate Number Report
Monthly Reports
Monthly/Quarterly Triples Activity Report
Monthly/Quarterly Operation Summary
Monthly/Quarterly Statistics Modification Report
Monthly/Quarterly Citation Modification Report
Monthly/Quarterly Productivity Progress Summary
Monthly/Quarterly Chronic Offender Report
Extract Functions
Manual Statistic Extract Function
Manual Citation Extract Function
Manual Percent Weight Changes Extract
Manual WIM/Statistic Raw Data Extract
Manual Daily Statistic Collection Function
Review Functions
Review Statistic Extract Tracking
Review Citation Extract Tracking
Review Percent Weight Changes Tracking
Review WIM/Statistic Raw Data Tracking
Review Update Batch Tracking
Review Daily Statistic Collection Tracking
Record Maintenance Application
Weigh Station Parameters Application

4.4 ACTUAL BENEFITS

4.4.1 GENERAL COMMENTS

Many of the potential benefits estimated in Section 3.4 never materialized. This is because to achieve all the benefits, the whole Oregon motor carrier fleet would have to carry transponders. This may occur in the future. Even so, the benefits realized were enough to make the system a success.

4.4.2 WIM SORTING BENEFITS

Benefits were received from sorting. The POE was designed to handle 2,400 vehicles during a 24-hour period, averaging 1,600 vehicles daily on a weekly basis. Maximum hourly peak volumes were to be 100 to 200 vehicles. Within two years, peak vehicle daily volumes have reached 3,500, with an average traffic volume of over 2,600. Peak hour volumes have sometimes reached 250. Table 4.3 shows the number of vehicles going through the POE by type and day of the week in 1988 vs 1993.

There is no way that the POE could handle all this volume without causing a backup of truck traffic onto the freeway, or installing a third static scale. The WIM sorter allowed the weighmaster(s) to reduce the volume by putting in a 30,000 pound [13,600 kg] gross vehicle weight threshold. Vehicles with transponders and those weighing 30,000 [13,600 kg] pounds or less were allowed to bypass the POE.

The WIM sorter has produced the following benefits: increased safety by preventing truck back-ups, and reduced the need for expansion of the POE and thus, saving the State money.

4.4.3 HUMAN RESOURCE SAVINGS

POE's are labor intensive, taking 60 percent of the weighmaster field crews. The normal crew size at Woodburn is 17. This automation has allowed for a one person reduction, allowing for a yearly savings of $27,400. This freed up one weighmaster to work on truck inspections or work at an outlying weigh station.

As the ODOT is reducing staffing levels to 90 percent of normal work levels, people are being asked to do more with less staff. Savings are welcome anytime. Under 100 percent transponder usage, human resource savings would be four weighmaster(s).

4.4.4 PRODUCTIVITY GAINS

The system has allowed for the reduction of 13 manual tasks to 4 for the weighmaster(s). This has reduced fatigue and stress. The system has allowed the weighmaster(s) to spot violators immediately, spot whether or not a truck had its safety inspection, and print citations and immediate reports. This has improved the weighmaster(s)' productivity and also has allowed for better personnel scheduling.

4.4.5 DATA STORAGE AND REPRODUCTION

The automatic storage of static scale weight data has saved PUC from keypunching this data. The yearly savings from keypunching the data have amounted to $10,000. Also, the fact that this data is sent to the ODOT mainframe within a day means that the auditors have up-to-date data at hand, which has improved trucking company audits.

4.4.6 IMPROVED WEIGHT ENFORCEMENT

The development of a chronic offender list has allowed the weighmaster(s) to do two things: 1) warn the chronic offenders of possible penalties; and 2) develop a chronic offender bail system with escalating fines.

Several companies have been warned and have corrected the situation. The automation of the POE should improve weight enforcement by punishing the chronic offenders.

4.4.7 IMPROVED SAFETY ENFORCEMENT

Weighmaster(s), with the help of the SC and database, are able to spot vehicles who have not been inspected recently and also identify vehicles/companies that have safety problems; this has improved safety enforcement.

4.4.8 IMPROVED TAX COLLECTION

The weighmaster(s) are now able to identify delinquent tax payers. For example, within six months of operation, a truck from a large trucking firm which has a history of tax evasion and poor payment, was stopped for non-payment of taxes. Before it was allowed to continue its journey, the firm had to pay $41,000 in back taxes to the PUC. This has speeded up tax collection.

TABLE 4.3 Comparison of the Number of Vehicles Weighed by Day of the Week 9/26 to 10/3/88 vs. 6/28 to 7/4/93 Woodburn Southbound POE

Year: / Week: / Day:	1988 9/26 -10/3 Weighings*	1993 6/28 - 7/4 Weighings*	Growth in Weighings Difference	Growth in Weighings % Change
Monday	3,204	3,723	+ 519	+ 16.2
Tuesday	3,293	3,835	+543	+ 16.5
Wednesday	3,194	3,972	+ 778	+ 24.7
Thursday	3,061	3,583	+522	+17.1
Friday	2,912	3,347	+435	+ 14.9
Saturday	1,348	1,059	- 289	- 21.4
Sunday	1,032	804	- 228	- 12.6
TOTAL	18,044	20,323	2,280	+ 12.6

* Weigh-in-Motion Sorter System

NOTE: That Saturday and Sunday are July 3 and 4. This would make the reported reduction in growth unrepresentative

4.4.9 ODOT DATA COLLECTION

Data on trucks is now in a relational database. Information can be obtained almost immediately. In the past, this information from the POE's could be obtained only manually, requiring much time and effort. Now, information on trucks, types, gross and axle weights, commodity, safety, taxation, and other information can be obtained with very little effort. These data can now be obtained from all POE's. This data can be used for planning purposes, design, enforcement, and tax collection.

4.4.10 TRUCK PRODUCTIVITY

Trucks that are allowed to bypass the scales save only one minute. This is not very much time savings. If the WIM sorter with AVI could have been installed in the highway itself and trucks sorted at high speeds, time savings could exceed four minutes

or more. This type of sorting is being planned for the Umatilla POE, and if successful, will be installed at other POE's.

4.5 IN RETROSPECT

When the project specifications were first developed, nobody on the Technical Advisory Committee or on the Steering Committee knew what kind of problems would occur, nor what would be needed. After nine months of operation, a better understanding of the limitations has been developed.

4.5.1 COMMUNICATIONS

The communications between the PUC mainframe and the SC should have been studied and further developed. An error tracking system in the data system between the two systems has been developed as a result.

4.5.2 FINE TUNING OF SOME FUNCTIONS

1. Hazardous materials identification codes needed to be put into the existing programs.

2. Simplification of some of the output and tables should be done. This would make some of the output easier to read for the weighmaster(s).

3. Development of an automatic calibration system for the WIM sorter needs to be done. The weights from the static scales would be used to calibrate the WIM whenever the statistics program shows certain levels of deviation.

4. Development of a comparison system for static gross weights versus registered gross weights. This is needed for cost responsibility studies.

5. Estimated costs of these changes would be around $30,000, and would update the system and smooth operations.

4.5.3 LIMITS OF AUTOMATION

The system is incapable of measuring truck widths or overall vehicle lengths. At present, no equipment is available which will measure these two parameters, which is a serious limitation of the automated system. Weighmaster(s) need the ability to enforce

these two important parameters. There is a need to get manufacturers interested in developing such equipment.

The complete success of the automation system at the Woodburn southbound POE will depend upon all trucks carrying some kind of identification which can be automatically read. The trucks with transponders in the demonstration has shown that this system can work successfully.

5.0 1988 FINDINGS, RECOMMENDATIONS, AND FUTURE PLANS

5.1 FINDINGS

5.1.1 POE PHYSICAL PLANT

The overall design of the physical plant, layout, and pavement has been a success. Because, in many ways, this was a prototype POE, some design problems did occur. Most were correctable.

5.1.2 AUTOMATION

The project is a success despite the fact that to obtain all the theoretical benefits, each truck operating in Oregon would need to carry a transponder. However, there are enough actual benefits to consider this experimental project a success.

These benefits were in the area of improved weight, safety, and tax enforcement, data collection, human resource savings, weighmaster productivity gains, vehicle sorting, and truck productivity.

5.2 RECOMMENDATIONS

5.2.1 PHYSICAL PLANT AND LAYOUT

1. All pavement within the scale area should be PCC. This should reduce maintenance costs in the future.

2. The WIM approach slab should be lengthened to minimize the truck dynamics. The total length should be at least 425 feet [130 m], 300 feet [91 m] in front of the WIM, and 125 feet [38 m] after the WIM.

3. The truck inspection building needs to be lengthened to 120 feet [37 m] to accommodate the longer combinations.

4. Future design of POE's should take into account the turning radii of trucks and truck combinations.

5. A faster and better variable message sign is needed.

6. Future design of the weighmaster/PUC housing should include a room for a computer and also have adequate wiring and outlets.

5.2.2 AUTOMATION

1. All POE's should be automated as quickly as possible. The benefits achieved at the Woodburn POE can be easily translated to the other POE's.

2. Oregon should adopt an AVI system as soon as possible and issue transponders as a license plate. This is the only way that the full benefits of automation can be obtained.

3. Full weighmaster and truck productivity gains will be obtained only if vehicles are sorted in the highway at high speeds. High-speed WIM sorter systems with AVI should be installed in highways before POE's accesses.

4. There is a duplication of computers with the WIM system having its own computer. This computer should be eliminated and WIM/AVI data should be collected, stored, and processed by the Motorola 8400 minicomputer. This would result in some savings and eliminate duplication of efforts.

5. A height, width, and length truck detector is needed to make the POE's truly automatic. Prototypes need to be tested as a demonstration project.

6. Some software modifications and additions are needed. These are:

   (a) Hazardous materials identification codes.

   (b) Simplification of some output and tables.

   (c) Development of an automatic calibration system for the WIM sorter using the static scale readings.

   (d) Comparison of registered gross weight versus actual static gross weights.

7. A plan should be developed to automate the permanent weigh stations using the existing Motorola computer and software. This statewide network as shown in Figure 5.1 would tie all data together on one relational database, and improve truck safety and enforcement in these outlying areas.

8. With the success of this automation project, unstaffed weigh stations are possible. The State should develop a plan to explore the feasibility of such a project.

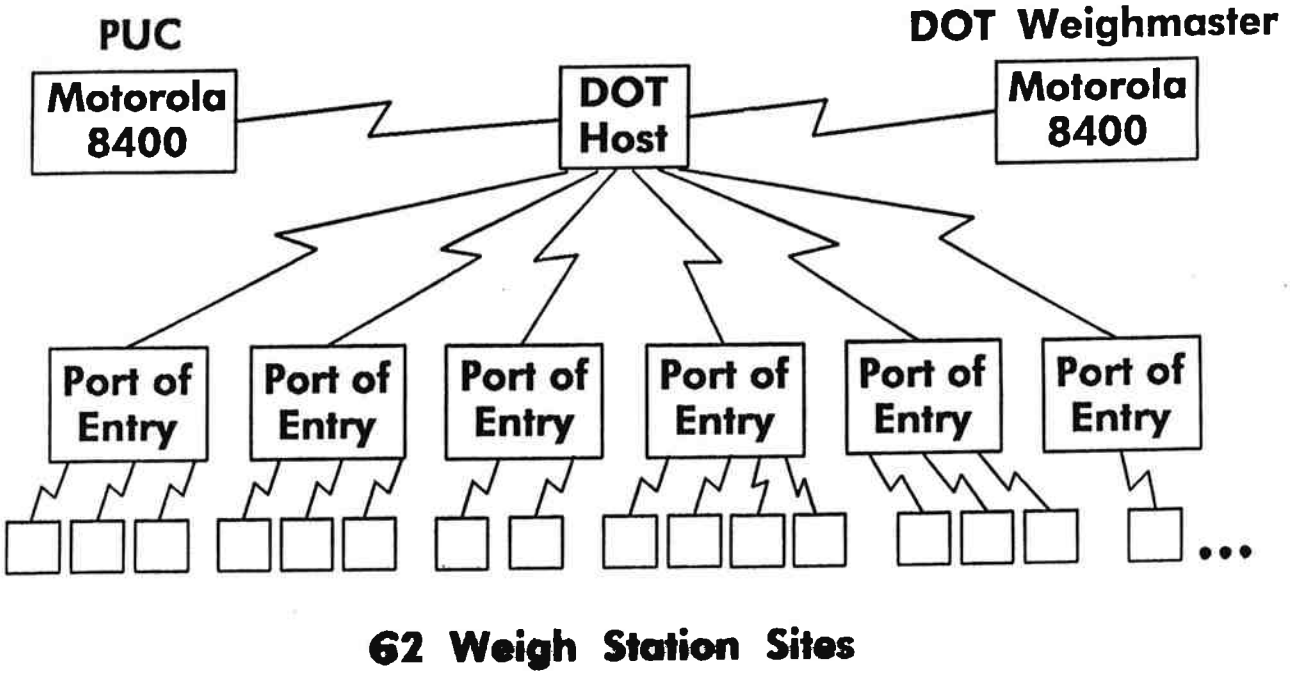

Figure 5.1: Statewide Network of Weigh Stations.

5.3 FUTURE PLANS AS OF 1988

The Weighmaster Unit has already accompanied or is planning the following projects based on the findings from the Woodburn POE:

1. Some design modifications were made at the new Cascade Locks POE based on the findings from the Woodburn POE physical plant and layout. These are also being taken into account for the proposed new Umatilla POE, and truck inspection bay buildings for the other POE's.

2. All POE's have been automated. These POE's are being retrofitted with sorter WIM/AVI systems as time permits and when funds become available.

3. Changes, modifications, and additions to the software have been contracted out to Motorola Computer Systems.

4. A high-speed mainline WIM sorter system is being planned to be installed and tested in the I-82 southbound lanes as part of the proposed Umatilla POE.

5. In addition, a demonstration project using piezo WIM/AVI/Detection systems for high-speed sorting on I-5 at the Woodburn POE is being planned.

6. A demonstration project to test prototype height, weight, and length detectors for trucks at two sites is being developed for future consideration.

7. Permanent weigh stations will eventually be automated within five years.

8. Plans for unstaffed weigh stations are being developed. Progress will depend upon the success of the piezo-WIM study underway and the Crescent Project.

6.0 FINDINGS AND RECOMMENDATIONS FROM FIVE YEARS OF OPERATIONS, 1988 - 1993

6.1 GENERAL COMMENTS

The Woodburn POE has been in operation since 1986. The automation system has been in continuous operation since 1987. Long term impacts can now be measured and calculated. Theoretical versus actual results can now be compared.

The system has worked beyond expectations. The weighmaster(s) have completely accepted the system and so have the trucking firms and drivers. The system has allowed for the successful operation of the POE despite the fact that the peak vehicle traffic has almost doubled and has exceeded the design capacity.

6.2 MODIFICATIONS

During the five years of operations, modifications have been made to the physical plant, WIM/AVI systems, and the automation system. Many of the recommendations made in previous chapters have been followed and implemented.

6.2.1 PHYSICAL PLANT

Some modifications have been made to the original POE layout and facilities design. The PCC entry pavement has been extended an additional 100 feet (31 m) by replacing some of the AC pavement in the entrance lane. This was done because the AC was rutting very badly at the junction with the PCC pavement. The truck inspection building was extended by 40 feet (12 m) so that triple trailers could be inspected under cover during inclement weather.

6.2.2 WIM SORTER SYSTEM

This system, similar to the one installed at the Woodburn weigh station along the I-5 northbound lanes, has worked very well with minimum down time. The scales, axle sensor, loops, overheight detector, and directional signal lights have worked very well. Scale accuracy for 5-axle semis has been within three percent for axles and two percent for gross weight. The only weak link has been the Dynax Axle Sensor, which fails in 12 to 24 months. The axle sensors cost $500 excluding installation.

6.2.3 AVI SYSTEM

The original AVI system was the General Railway Signal system, originally tested in 1984 -85 at three sites (*4*). This was in place in 1986 with about 350 trucks carrying the transponders. Since Oregon is part of the HELP Crescent Demonstration Project, the recommended AVI system with readers and transponders was installed. Some 1,100 Oregon registered trucks carry this transponder. These AVI systems are operating satisfactorily.

6.2.4 AUTOMATION SYSTEM

Krukar and Evert (*7*) have described this system in general. The software programming and functions have been described by Rytter (*8*). The electronic hardware, the accompanying software, and software interfaces have worked very well. The system was accepted by the field users for several reasons including:

1. The programmers and weighmaster staff worked directly with the operators.

2. The field weighmaster(s) were represented on the Technical Advisory Committee and given input in the initial design.

3. Their tasks were simplified from thirteen to four steps.

4. The weighmaster(s) and managers had instant information, menus, and tables (see Table 4.2) that provided opportunities to increase efficiency and develop useful information for facilities operation.

Some software upgrades have been made. The custom code has been revised four times. Software modifications have been made to simplify some tables, add additional information, and comply with changes to the citation format mandated by the State Supreme Court.

The SC storage capacity needs to be upgraded, and faster responses are needed. The additional information and growth of traffic has slowed average data processing time from 125 milliseconds to 147 milliseconds (maximum processing time has exceeded 600 milliseconds during peak periods). In other words, the present electronic system is becoming obsolete.

6.3 SYSTEM COSTS

These costs are for the physical plant and downtime and maintenance costs.

6.3.1 PHYSICAL PLANT

The POE costs for land, buildings, and pavement came to $2,200,000. The additional work cost $100,000, so the total was $2,300,000. Automation cost was $412,000. Total costs were $2,712,000. Table 6.1 shows the costs by item.

TABLE 6.1 The Costs for the Woodburn POE and WIM/AVI/Automation

Item	Cost - $
POE: land, construction, buildings and additions	2,300,000
WIM/AVI (Includes WIM-4 computer)	200,000
WIM/AVI/SC Communications Software Interface	10,000
SC and Accessory Electronics Hardware	55,000
SC Software (custom/data/database)	45,000
Functional Specification	12,000
Variable Upgrade #1	30,000
Variable Upgrade #2	10,000
Variable Message Signs	50,000
TOTAL	2,712,000

6.3.2 DOWNTIME AND MAINTENANCE COSTS

Monthly records from Woodburn show that downtime for all the automation components averaged four hours per month or 48 hours per year. Maintenance costs, including parts and labor, averaged $2,500 per year or about $208 per month. A maintenance contract was in effect with Motorola. Monthly SC electronics and software maintenance charges were $472, or $5,664 yearly.

6.4 IMPACTS

There have been impacts on POE functions, weighmaster functions with respect to crew size, productivity gains, performance measures and crew deployment. Impacts have been measured on PUC functions such as weight-mile tax collection, tax audit productivity, and personnel productivity including time savings and improved competitive edge.

6.4.1 POE FUNCTIONS

Tables 4.3 and 6.2 show that the vehicle traffic has exceeded design estimates. Empties are not weighed at the static scales; all other vehicles are weighed unless they are allowed to bypass. The WIM sorter system gross weight threshold was initially set at 30,000 pounds [13,600 kg], meaning that legal vehicles under 30,000 pounds [13,600 kg] were allowed to bypass the static scales. The increase in traffic has forced this gross weight threshold to be set to 50,000 pounds [22,700 kg]. About 50 percent of the vehicles weighed by the WIM sorter are allowed to bypass.

TABLE 6.2 Percent of Vehicles Screened by Woodburn POE Sorter System * 6/28 to 7/4/93

Day	Number of Vehicles				Percentage of Vehicles Screened by WIM
	Recorded by WIM		Weighed by		
	Total	Empty	WIM	Static Scale	
Monday	3,723	1,032	2,691	1,020	62.1
Tuesday	3,835	1,108	2,727	1,414	48.1
Wednesday	3,972	1,051	2,921	1,573	46.1
Thursday	3,583	1,006	2,577	1,296	49.7
Friday	3,347	936	2,411	1,221	49.3
Saturday	1,059	248	811	523	35.5
Sunday	804	182	622	505	18.8
TOTAL	20,323	5,563	14,760	7,552	48.8

NOTE: That Saturday and Sunday are July 3 and 4; this might make the reported values unrepresentative

* This does not include empty vehicles with scale manipulated errors. Therefore, on some days the number of vehicles easily exceeds 4,000 per day.

If the WIM sorter system had not been in place, the system would have been clogged with time delays for trucks due to queuing, and potential safety problems. By 1992, the weighmaster(s) would have had to install another static scale, scale house, and lane. The estimated cost for a third scale and accessories is $175,000.

6.4.2 WEIGHMASTER FUNCTIONS

Crew Size:
The original crew size was 18. The WIM/AVI automation system has allowed the crew to be reduced by two to 16. This has resulted in monthly fully loaded salary savings of $3,260 per person or $39,120 yearly. For two people, annual salary savings are $78,200, totaling for the five years $391,000.

If a third scale had to be installed, three more weighmaster(s) would have had to be hired in 1993. Their annual fully loaded salaries would have totaled $117,360. In addition, two crew members would have been needed during the four operations before the third scale was opened. The annual salary savings for two persons are $78,200 and $391,000 for the five-year period.

Daily staffing requirements have been reduced from six to five persons from Monday to Friday. On Saturday and Sunday shifts, staffing requirements have been reduced from four to three persons.

Total salary savings are $273,800 annually and $599,400 for the five year period (Table 6.3).

Productivity Gains:
Originally, the Woodburn POE crew also was in charge of four outlying stations located at Woodburn I-5 northbound, Hubbard Highway 99E northbound and southbound, and Tillamook. This responsibility has been increased by two more additional stations located at Molalla and Dayton. The crew is weighing more vehicles with less people.

Weighmaster(s) normally had to perform 13 manual tasks to weigh trucks and record data. The system has reduced this to 4. The result has been to improve morale and reduce stress and fatigue, as demonstrated by a significant reduction in sick leave usage.

The SC system has allowed the weighmaster(s) to identify potential violators immediately, thus improving weight enforcement and tax collection. In addition, the files in the SC let the weighmaster(s) know if the truck has a valid safety inspection sticker, and, if expired, automatically flag it for safety inspection. This improves safety inspection and benefits the public by providing safer highways.

The summary tables automatically prepared by the SC allows the POE supervisors time for other duties. Past information can now be located, where before mountains of paperwork needed to be sorted.

The ability to set the SC override of the legal WIM gross weight threshold to 50,000 pounds has reduced the number of non-transpondered trucks needing weighing in a 24-hour period from 3,000 - 4,000 trucks per day to 2,000 - 2,600 per day (Tables 4.3 and 6.2). This enabled the weighmaster(s) to bypass small light trucks and focus closer attention on heavier vehicles for size, weight, and safety inspection.

Performance Measures:
ODOT is developing performance measures for all units. The Woodburn POE, because of all the data, was one of the first crews to be placed on the productivity incentive matrix. In 1992, the crews earned an additional $5,200 in cash bonuses each for the year.

Crew Deployment:
The Woodburn POE supervisor is also in charge of six outlying weigh stations and portable scale operations in the area. The SC has allowed for more efficient scheduling of personnel for additional weigh station operations on other highways. This has increased the number of weighings on those routes, thus enhancing weight and size enforcement.

6.4.3 PUC FUNCTIONS

Weight-Mile Tax Collection:
The automated system at this POE has increased the collection of truck weight-mile taxes through improved truck weight information. PUC staff estimates this at $11,500 annually or $57,500 during the five-year period.

Trucking firms behind in their tax payments are now identified at the POE, although tax audits would have caught them eventually, since they are supposed to be audited every two years. The automation system allows this to happen in a more timely manner. One large trucking firm was apprehended owing $41,000. These delinquent taxes and reinstatement fines were collected before the vehicle was allowed to leave the POE. Thus, PUC staff was alerted to audit this carrier more closely and was able to reduce the loss of interest in this account.

Tax Audit Productivity:
Productivity gains have come from more efficient and immediate truck weight information resulting in improved tax audits. Automation eliminates the keypunch errors made by PUC operators. The data is now more reliable, up-to-date, and current, thus helping with tax audits. All this results in more efficient truck weight-mile tax collection.

TABLE 6.3 Summary of Savings from Automation to the State and Private Industry

Beneficiary	Source	Function	Annually $	5-Year Total $
A. STATE	Weighmaster	a. Automation Crew Reduction (2)	78,200	391,000
		b. No Automation		
		POE Expansion Postponement[1]	175,000	175,000
		Additional Crew Need (3 for 1 yr)[2]	117,400	117,400
		Normal Crew (2 for 5 yrs)[3]	78,200	391,000
Subtotal			448,800	1,074,400
	PUC Motor Carrier Services	a. Data Entry	10,000	50,000
		b. Tax Collection	11,500	57,500
Subtotal			21,500	107,500
STATE TOTAL			470,300	1,181,900
B. PRIVATE INDUSTRY	Trucking	a. Time Savings[4]	286,300	1,431,500
PRIVATE INDUSTRY TOTAL			286,300	1,431,500
C. TOTAL SAVINGS			756,600	2,613,400
D. AVERAGE ANNUAL SAVINGS OVER 5-YEAR PERIOD				
a. State				236,380
b. Private Industry				286,300
c. Total				522,680

1 Third scale and house, equipment, and lane installed in 1992 and in operation during 1993.
2 Three additional crew members would be needed to run the third scale.
3 If there was no automation, the normal crew size would be 18, two more than for automation.
4 Truck operating costs are estimated to be $60 per hour. Only 50 percent of trucks would report to static scales.

Personnel Productivity:
The automatic storing of truck data in the SC from the WIM and static scales, and automatically transferring this data to ODOT mainframe computer on a daily basis has reduced the need for manual data entry. This has freed the use of this person for other duties. PUC staff estimates monetary savings to be $10,000 per year.

Safety Enforcement Enhancement:
The vehicle safety files contain information on truck safety inspections. This enables the weighmaster(s) and PUC safety personnel to know if the truck's safety inspection is current and whether the carrier has a high or low safety profile. This system has improved and increased truck vehicle safety inspections. This data is also utilized by safety auditors when performing on-premise investigations of a carrier's log books and after-the-fact safety audits.

6.4.4 DATA COLLECTION

Various ODOT functions have and will be benefiting from improved truck weight data. Data from the WIM and static scales are now available on the ODOT mainframe computer and can be used for planning, pavement design, research, traffic engineering, and cost responsibility. In the past, this data was available, but had to be processed manually and was very costly to collect and access. Now it is available immediately on a daily and weekly basis. Also, databases are being set up on truck freight commodities and weight.

6.4.5 TRUCK PRODUCTIVITY

Time Savings:
The automated POE allows 50 percent of the trucks to bypass the static scales and PUC office. This minimizes time losses. Time savings are on the order of 60 to 120 seconds per vehicle, which results in savings in operating costs amounting to $286,260 to $572,130 annually.

If all trucks had transponders, as much as 85 percent of the vehicles would bypass the static scales. If mainline sorting could be installed at Woodburn, estimated time savings per vehicle would be about five minutes.

Competitive Edge:
The improved enforcement of weight limits and safety helps the legitimate trucking firms and improves their competitive situation by reducing illegal or unethical operations.

6.5 SUMMARY OF SAVINGS AND COSTS

6.5.1 SAVINGS

The savings to the State and private industry from the WIM/AVI/SC automation system have been summarized in Table 6.3. Savings to the State are $470,300 annually and $1,181,900 for the five years of operation. Private industry savings are $286,300 annually, amounting to $1,431,500 during the five-year period. Total annual savings, State and private industry, amounted to $757,000 and $522,680, respectively.

6.5.2 COSTS

The costs for POE facilities and the automation system are shown in Table 4.3. Table 6.4 shows the total costs of WIM/AVI/SC hardware and software which amounts to $362,000. Annual maintenance costs for WIM and hardware/software are $8,200, amounting to $80,500 for the five-year period. Average annual costs over the five-year period amounted to $88,500.

TABLE 6.4 Summary of Costs* from Automation

Beneficiary	Source	Annually $	5-Year Total $
WIM/AVI	Hardware	200,000	200,000
	Software Interface	10,000	10,000
Total		210,000	210,000
WIM/AVI/SC	Hardware	55,000	55,000
	Functional Specifications	12,000	12,000
	Software	85,000	85,000
Total		152,000	152,000
Maintenance	WIM Sorter	2,500	12,500
	Hardware/Software	5,700	68,000
Total		8,200	80,500
TOTAL COSTS		370,200	442,500
Average Costs annual Over 5-Year Period			88,500

* Costs for POE's are excluded (see Table 6.1).

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7.0 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

The present WIM/AVI/SC automation system at the Woodburn POE has been amazingly successful, despite the fact that very few trucks have transponders. There have been both monetary and non-quantifiable benefits to ODOT, PUC, and the trucking industry. The result of this success has led to the automation of other POE's, excluding the WIM sorter system. WIM sorter system installation is planned for the future.

Based on ODOT experiences with Woodburn, mainline sorting has been installed at the new Umatilla POE in I-82 southbound lanes and at the Wilbur and Booth Ranch weigh stations located near Roseburg in the I-5 southbound and northbound lanes, respectively. These systems presently use variable message signs. The system at the Ashland POE on the I-5 northbound lanes will use mainline sorting with two-way communication on AVI systems to screen vehicles five miles from the POE.

The success of the Woodburn POE project has resulted in the weighmaster(s) developing an integrated tactical enforcement network plan (*9*) utilizing the electronic hardware and software principles. This is shown in Figure 5.1. In addition, a strategic/business plan for a statewide IVHS-CVO system is in the making (*10*).

The complete success of the automation system at the Woodburn POE and other POE's will depend upon all trucks carrying some kind of identification which can be automatically read. The trucks with transponders in the demonstration has shown that this system can work successfully. The WIM sorting system by itself has shown that it can successfully reduce truck volumes and improve POE truck movement as well as providing significant economic enhancements.

7.2 LIMITS OF AUTOMATION

The system is incapable of measuring truck width or overall vehicle length. At present, no equipment is available which will measure these two parameters, which is a serious limitation of the automated system. Weighmaster(s) need the ability to enforce these two important parameters. There is a need to get manufacturers interested in developing such equipment.

7.3 FUTURE RESEARCH NEEDS

Research needs to make these systems more effective and usable under mainline sorting conditions include the following:

1. Automated vehicle width/length/height measurements. This would allow extra legal movements to be checked for compliance with state-issued variance permits.

2. WIM systems capable of self-calibration/correlation with static scales. This will allow a reduction in legal vehicles being brought into the station and a reduction in overloaded vehicles being allowed to bypass as reported by Krukar and Evert (*11*).

3. Driver identification. A means is needed to identify drivers of vehicles to ascertain compliance with driver qualifications and hour of service requirements.

8.0 REFERENCES

1. Krukar, Milan and Ken Evert, "The Metamorphosis of Weight Enforcement Strategies in Oregon," Proceedings, 3rd National Weigh-in-Motion Conference, St. Paul, Minnesota, October 1988.

2. Krukar, Milan and Ken Evert, "Weight Enforcement Strategies in Oregon from 1921 to 1990 and Beyond," Proceedings, 40th Annual Roadbuilders' Clinic, Moscow, Idaho, March 1989.

3. Henion, Loyd, "Weigh-in-Motion, New Technology to Assist Us in Managing Our Highway Investment," Proceedings, First National Weigh-in-Motion Conference, Denver, Colorado, July 1983.

4. Krukar, Milan, "Oregon Weigh-in-Motion and Automatic Vehicle Identification Demonstration Project," Final Report, State Highway Division, Oregon Department of Transportation, Salem, Oregon, September 1986.

5. Krukar, Milan, "Woodburn southbound POE Automation Experimental Project," White Paper, Planning Section, Highway Division, Oregon Department of Transportation, Salem, Oregon, March 1986.

6. Krukar, Milan, "Request for Proposals - Consultant Services, Software, and Hardware for the Automation of Woodburn southbound POE." Permits and Weighmaster(s) Section/Planning Section, Oregon Department of Transportation, Oregon, May 22, 1986.

7. Krukar, Milan and Ken Evert, "The Automation of the Woodburn southbound POE on Interstate 5," Proceedings, The Third National Weigh-in-Motion Conference, St. Paul, Minnesota, October 1988.

8. Rytter, D. A., Functional Specifications for Woodburn POE Project, Motorola Computer Systems, Inc., April 1987.

9. Krukar, Milan and Ken Evert, "Integrated Tactical Enforcement Network (Automated Enforcement Facilities in Oregon)," Proceedings, National Traffic Data Acquisition Technologies Conference, Austin, Texas, August 27 - 30, 1990.

10. "Strategic Plan for IVHS/CVO in Oregon," ODOT and OPUC, July, 1993.

11. Krukar, Milan and Ken Evert, "Mainline Screening for Enforcement," Proceedings, National Traffic Data Acquisition Conference, Sacramento, California, October 25 - 29, 1992.