

WOODBURN PORT-OF-ENTRY AUTOMATION PROJECT

1986 - 1993

Final Report

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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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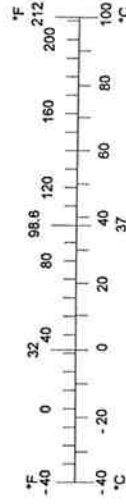
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
<u>AREA</u>				
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
<u>VOLUME</u>				
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 .				
<u>MASS</u>				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
<u>TEMPERATURE (exact)</u>				
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
<u>AREA</u>				
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
<u>VOLUME</u>				
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
<u>MASS</u>				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
<u>TEMPERATURE (exact)</u>				
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

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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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1.0 INTRODUCTION

In 1986, the Oregon State Highway Division¹ (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) Unit² and Economic Services Unit, Planning Section³, 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

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 ODOT⁴. 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.

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 maintenance;
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:

$\$1,730/\text{month} \times 12 \text{ months} + 32 \text{ percent benefits} \times 4 \text{ people} = \$109,613$

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:

$$\begin{aligned} &60 \text{ seconds} \times \$1.00 \text{ per minute operating costs} \\ &\times 85\% \text{ (2,000 daily truck average)} \times 365 \text{ days} = \$620,500 \end{aligned}$$

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	<u>\$ 11,500</u>
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:

$$\begin{aligned} &60 \text{ seconds} \times \$1.00 \text{ per minute operating costs} \\ &\times 600 \text{ trucks per week} \times 52 \text{ weeks} = \$31,200 \end{aligned}$$

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	<u>\$ 11,500</u>
Total	\$ 21,500

3.3.3 Pay Back Period

Costs of Automation of POE:

WIM	\$200,000
AVI	\$ 24,000
Automation	<u>\$100,000</u>
Total	\$404,000

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

$$\text{Pay-back period} = \$404,000 \div \$131,000 = 3.1 \text{ years}$$

$$\text{Pay-back period} = \$404,000 \div \$22,000 = 18.4 \text{ years}$$

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.