Findings from Five Years of Operating Oregon's Automated Woodburn Port of Entry

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In 1987 the Oregon Department of Transportation automated the new Woodburn port of entry (POE), located on Interstate Highway 5 southbound at milepost 274.40. The reasons were to minimize weighmaster and public utility commission tasks; improve weight, size, and safety enforcement; provide more data for planning and design purposes; maximize Weighmaster resources; improve tax collection and audit capabilities; and save time for the trucking industry. Automation of the Woodburn southbound POE interfaced six components: (a) weigh-in-motion sorter scales, (b) automatic vehicle identification system, (c) electronic static scales, (d) supervisory computer, (e) various software interfaces, and (f) motor carrier data base. The findings from this automation on the basis of 5 years of operation show improvements and cost savings in (a) weighmaster functions, (b) performance measures, (c) POE operations and functions, (d) human resources deployment, (e) data collection, (f) tax audit trails, (g) tax collection, and (h) the private motor carrier industry.

In 1987 the Oregon Department of Transportation (ODOT) automated the new Woodburn port of entry (POE), located on Interstate 5 southbound at Milepost 274.40. The reasons were to minimize weighmaster and public utility commission (PUC) tasks, improve weight, size, and safety enforcement, provide more data for planning and design purposes, maximize weighmaster resources, improve tax collection and audit capabilities, and save time for the trucking industry.

This was a demonstration project jointly funded by ODOT and FHWA. In addition, this project is part of the HELP Crescent demonstration. Funding of the latest automatic vehicle identification (AVI) equipment was through HELP. This paper presents the findings from this automation on the basis of 5 years of operation, 1988 to 1993.

BACKGROUND

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 truckers operate safely and efficiently within Oregon's laws (*1*). This service concept has evolved into "one-stop shopping" where the facilities are built to weigh heavy vehicles, provide PUC services, and conduct truck safety inspections. PUC and weighmaster personnel are now located in the same building and there is a truck inspection facility with two bays. Delays are minimized as much as possible.

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ODOT, through the weighmasters, operates six POEs besides 65 weigh stations and 19 mobile enforcement sites and conducts statewide portable scale operations. These six ports are located at Woodburn I-5 southbound (SB), Ashland I-5 northbound (NB), Cascade Locks I-84 eastbound, Farewell Bend I-84 westbound, Umatilla I-82 SB, and Klamath Falls Highway 97 NB. These ports principally monitor Interstate traffic entering Oregon.

Three of these ports were built between 1975 and 1982. The initial design for the Woodburn POE began in 1982. Before the Woodburn SB POE was built, the three existing ports did not entirely meet the one-step shopping concept. The weighmasters and PUC decided in this initial design phase to consider the idea of combining weight and size enforcement, PUC permits, and truck safety inspection at one location.

In late 1983 the Oregon State Highway Division started a weigh-in-motion (WIM) and AVI demonstration project, testing a medium speed WIM data collection system with AVI on I-5 NB at Jefferson. The results have been reported by Krukar (*2*).

In late 1984, on the basis of the initial success of the WIM/AVI Demonstration Project, the idea of interfacing WIM/AVI with the static scale and installing a supervisory computer (SC) with appropriate software to monitor, store, modify, hold the PUC data base, and transfer weight data was discussed. This concept developed into the Woodburn SB POE Automation Demonstration Project as described by Krukar (*3*). Construction on the Woodburn POE started in 1985.

AUTOMATION OF WOODBURN POE

Need for Automation

The Woodburn POE is the busiest port in the state. All POEs are operated around the clock, 7 days a week. A minimum of 2,000 trucks pass through this facility during a 24-hr period. During peak periods, more than 4,000 trucks per day pass through the POE. As many as 150 to 200 trucks may pass through during a peak hour.

When this POE was designed, it was estimated that the port would handle an average of 1,700 vehicles per day with peak days of 2,200 to 2,300. These estimates have been exceeded, and there was a need to lessen this workload increase on the weighmasters. POEs are labor intensive for the weighmasters, requiring 60 percent of the field staff to be dedicated to POE operation.

The automation of the port was an answer to this need. Automating the system would provide long-term increases in productivity, resulting in reduced manpower 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.

Components

The automation of the Woodburn SB POE consists of six elements: (a) the WIM sorter, (b) the AVI system, (c) the electronic static scales, (d) the supervisory computer, (e) various software interfaces, and (f) the Motor Carrier data base. Table 1 presents the components used in this project.

POE FUNCTIONS

Operations Functions

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

The purpose of the weighmasters is to protect Oregon's highways from overloaded and oversized trucks and to monitor truck safety and the transport of hazardous materials. Their functions are tied to their purpose. Weighmasters' functions are to weigh trucks to ensure that they are legal with respect to gross, axle, and tandem-axle weight, height, width, and length and to comply with federal bridge formula. Weighmasters have statutory authority to control weight, size, and safety and cite violators. They, along with PUC, monitor trucks for safety and the transport of hazardous materials. The weight information is used by PUC for weight-distance tax audits.

PUC has both regulatory and tax collection functions. The Motor Carrier Division's functions at POEs are to collect weight-distance taxes from those vehicles that 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 weighmasters although PUC has statutory responsibility and lead agency status in safety compliance.

At present, a weighmaster takes 20 to 40 sec to weigh a truck at a static scale, depending on the truck type. More time is needed if the truck is found to be in violation. The weighmaster manually records the truck identification, commodity, number of axles, gross weight, and axle weights. Thirteen manual tasks are required to complete the previously given procedure. This information is sent to the PUC Motor Carrier Division, where it is manually entered into the ODOT mainframe computer. This information is used for tax audit purposes.

About 85 percent of the trucks passing through the POE have appropriate PUC papers and are within legal weight. The remaining 15 percent either are cited for some kind of weight or size violation or need an extended weight permit or a PUC permit for

TABLE 1 Equipment and Software Used in POE Automation

Type	Manufacturer	Model	Amount
WIM Sorter	CMI-Dynamics	SS 200-IDC (R)	1
AVI Transponders	General Railway Signal	01320-30	350
Reader-Activator	General Railway Signal	41795	1
Antennas	General Railway Signal	59656-12/13	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	
Mainframe Communications	Motorola	SNA 3270/3770	1
Rational Database Custom Software	Informix/Motorola*	4th Generation Language for Customware Programming	1

* Motorola is no longer in the business of supplying this type of software.

weight registration, or both. These trucks will have to go to the legalizing loop and park. Truck drivers will have to make a stop that may vary from 5 to 25 min longer if their load is weight illegal and has to be adjusted or removed. Extra time is needed by the weighmaster to write citations.

Automated Functions

The automated system at the Woodburn POE allows trucks with transponders to bypass the static scales and the PUC office. A total of 85 percent of the transponder-equipped trucks will be able to take advantage of this, minimizing their productivity losses. A truck with a transponder has its identification number read by the AVI reader and is also weighed and height monitored by the WIM scale and height detector. These data are transmitted to the SC where they are stored for future transfer to the ODOT mainframe computer. The SC has data on 250,000 vehicles, which includes information about whether any given PUC plate is suspended or for some other reason is invalid. This allows the weighmaster to take immediate action in cases of suspended plates. In the past this information was not readily available to provide timely action at the POE. The SC also has name and address files on 40,000 carriers. If the transpondered truck meets both the weight and height limits and registration requirements, then it is automatically permitted to bypass the static scales and the PUC office, minimizing time loss.

If the WIM scale shows that the truck does not meet gross or axle weight limits or bridge formula or oversize criteria, or both, and the SC shows that it meets PUC requirements or safety inspection validation, or both, then the truck has to go only to the static scales to be weighed. If in violation, the driver receives a citation, which is printed automatically. If the WIM scale shows that the weights are legal but the SC shows that the PUC registration requirements are not met, then the truck can bypass the static scales but still has to go to the PUC office to have its credentials reviewed and obtain the necessary papers. If the truck violates both the legal weight limits and size limits and the PUC requirements, then the truck goes to both the static scales and the PUC office. This automated system reduces the number of vehicles going to the static scales by almost 50 percent. All WIM data are stored and telemetered daily. The WIM data on trucks that are allowed to bypass the static scales and PUC office are transferred and stored on the SC computer.

The linking of the Weightronix static scales to the SC allows the automatic recording and storing of the static weights. The weighmaster directly enters the truck identification (PUC number) with the commodity data number into the SC. This automated system improves weighmaster productivity by reducing the present 13 manual tasks to 4. PUC saves on keypunch operator time and keypunching errors. The system also allows the audit staff to have near real-time data available during carrier audits, thus improving the effectiveness of the audit.

Safety inspection information is also in the SC files. Weighmasters can tell when a truck was inspected. If the truck has not been inspected recently, the system can automatically send it to the safety inspection bay. The SC also has available the necessary programs to utilize the Federal Motor Carrier Safety Class Rating Code.

The static weight information, along with the WIM information on trucks bypassing the static scales, is stored and transferred to the ODOT mainframe computer. The SC provides the weighmaster a daily summary of the number and types of vehicles weighed at the static scales and the number of violations by type. PUC is able to update the vehicle files to the SC on a near real-time basis. This is currently done on a 3-hr basis because of the necessity to control batch size.

The combination of AVI, SC, and WIM permits trucks to bypass the static scales and the PUC office, provided they meet both PUC and weight limit requirements and regulations. A POE with a WIM sorter scale, but without AVI and SC, will not permit trucks to bypass the PUC station—only the static scale. Therefore, an AVI and SC system are needed to make the POE automation demonstration work properly.

Originally, only 350 trucks were equipped with transponders. This has now been increased to 1,100. Approximately 100 trucks with transponders pass through the Woodburn POE daily. This limited system demonstrates the feasibility of the fully automated POE and demonstrates even more forcefully the improved productivity of the weighmasters.

Figure 1 shows the location of the various aspects of the automation system.

FIVE YEARS OF OPERATION

General Comments

The port with the WIM sorter system and AVI opened in January 1987. In December 1987 the automation software, the SC, and accessory electronic equipment were put in place and tested. Full operation started in January 1988. The system and operation have been described in detail by Krukar and Evert (*4*).

The system has worked beyond expectations. The weighmasters have completely accepted the system and so have the trucking firms and drivers. The system has allowed for successful operation of the port despite the fact that the vehicle traffic has almost doubled and has exceeded the design capacity.

Some modifications have been made to the original port layout and facilities design. The portland cement concrete (PCC) entry pavement has been extended an additional 100 ft by replacing some of the asphalt concrete (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 ft so that triple trailers could be inspected under cover during inclement weather.

WIM Sorter System

This system, similar to the one installed at the NB Woodburn weigh station on I-5 NB, 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 tractor-semitrailers has been within 3 percent for axles and 2 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.

Automation System

Krukar and Evert have described this system in general. The software programming and functions have been described by Rytter

(5). The electronic hardware, the accompanying software, and software interfaces have worked very well. The system was accepted by the field users. One of the reasons is that the programmers and weighmaster staff worked directly with the operators. The second was that field weighmasters were represented on the Technical Advisory Committee and given input in the initial design. The third reason was that their tasks were simplified from 13 to 4 steps. Fourth, the weighmasters and managers had instant information, menus, and tables (see Figure 2) that provide 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.

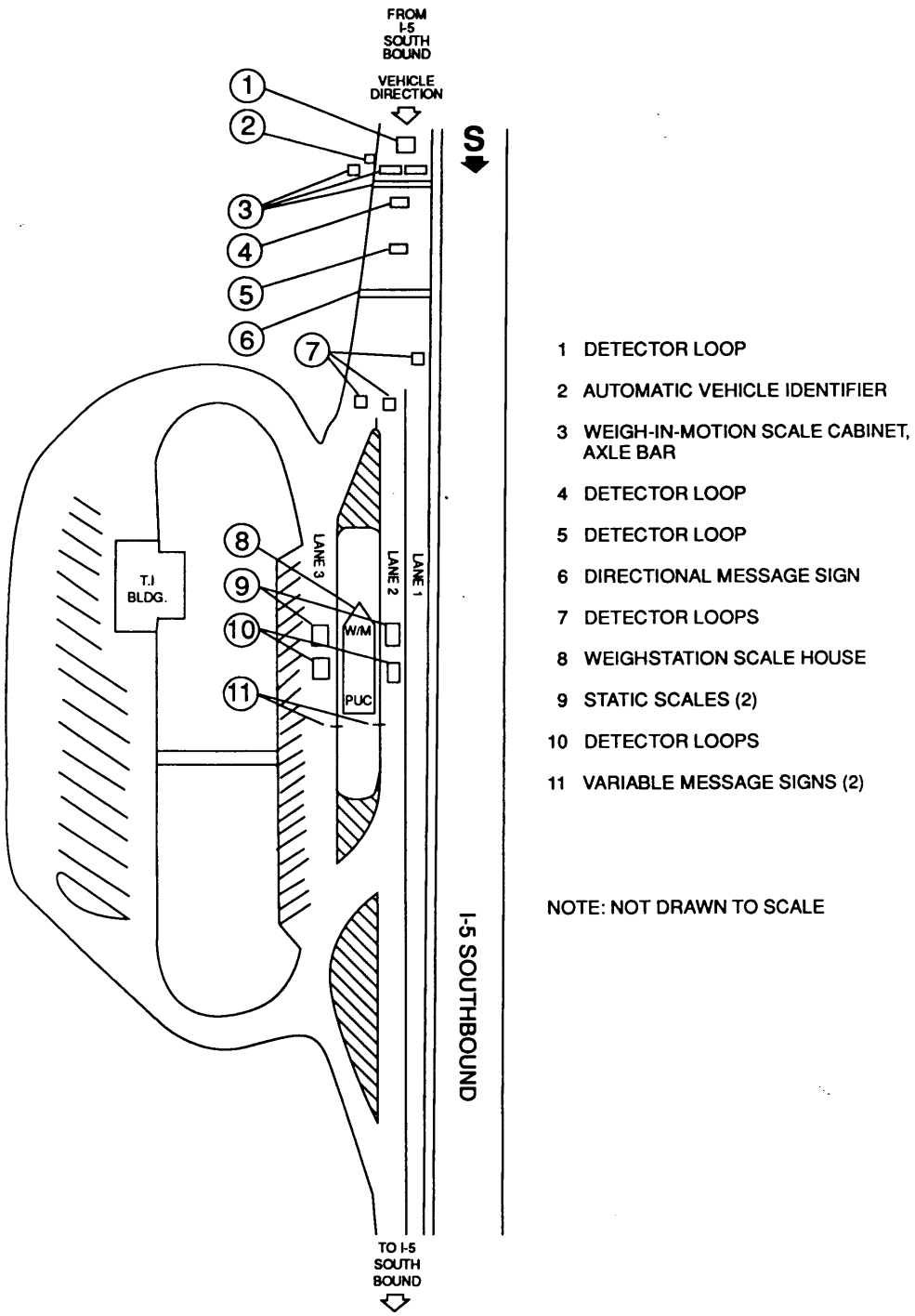

FIGURE 1 Woodburn SB POE.

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

AVI System

The original AVI system was the General Railway Signal system, originally tested in 1984 to 1985 at three sites (*2,3*). This was in place in 1986 with about 350 trucks carrying the transponders. Because 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.

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 Weigh
  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

FIGURE 2 Hierarchical Menus Used in Application System.

Downtime and Maintenance Costs

Monthly records from Woodburn show that downtime for all the automation components averaged 4 hr/month or 48 hr/year. Maintenance costs, including parts and labor, averaged $2,500/year or about $208/month. In a maintenance contract with Motorola, monthly SC electronics and software maintenance charges were $472, or $5,664 yearly.

Costs of Systems

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 $412,000. Total costs were $2,712,000. Table 2 presents the costs by item.

FINDINGS

POE Functions

Tables 3 and 4 indicate 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 lb, meaning that legal vehicles under 30,000 lb were allowed to bypass the static scales. The increase in traffic has forced this gross weight threshold to be set to 50,000 lb. About 50 percent of the vehicles weighed by the WIM sorter are allowed to bypass.

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

Weighmaster Functions

Crew Size

The original crew size was 18. The WIM/AVI automation system has allowed the crew to be reduced by 2 to a total of 16. This has resulted in monthly fully loaded salary savings of $3,260/person or $39,120/year. For two people, annual salary savings are $78,200, totaling $391,000 for the 5 years.

If a third scale had to be installed, three more weighmasters 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 5-year period.

Daily staffing requirements have been reduced from six to five persons from Monday through 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 5-year period (Table 5).

Productivity Gains

Originally, the Woodburn port crew also was in charge of four outlying stations located at Woodburn I-5 NB, Hubbard Highway

TABLE 2 Costs for Woodburn POE and WIM/AVI/Automation

Item	Cost - $
Port-of-Entry: land, construction, buildings and additions	2,300,000
WIM/AVI	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 Variable Upgrade #2	30,000 10,000
Variable Message Signs	50,000
TOTAL	2,712,000

TABLE 3 Comparison of Number of Vehicles Weighed by Day of Week: Woodburn SB POE

Year:	1988	1993	Growth in Weighings	
Week:	9/26 - 10/3	6/28 - 7/4		
Day:	Weighings*	Weighings*	Difference	% 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

99E NB and SB, and Tillamook. This responsibility has been increased by two more additional stations located at Molalla and Dayton. The crew is weighing more vehicles with fewer people. Weighmasters normally had to perform 13 manual tasks to weigh trucks and record data. The system has reduced this to four. 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 weighmasters to spot potential violators immediately, thus improving weight enforcement and tax collection. In addition, the files in the SC let the weighmasters 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 lb has reduced the number of non-transpondered trucks needing weighing in a 24-hr period, from 3,000 to 4,000 trucks per day to 2,000 to 2,600 per day (Tables 3 and 4). This enabled the weighmasters 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 put 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 also is in charge of six outlying weigh stations and portable scale operations in the area. The SC has allowed for more efficient scheduling of manpower for additional weigh station operations on other highways. This has increased the number of weighings on those routes, thus enhancing weight and size enforcement.

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 estimates this increase at $11,500 annually or $57,500 during the 5-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 2 years. The automation system allows auditing 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 port. Thus, PUC was alerted to audit this carrier more closely and was able to reduce the loss of interest in this account.

TABLE 4 Percentage of Vehicles Screened by Woodburn POE Sorter System

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

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

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 are now more reliable, up-to-date, and current, thus helping with tax audits, all of which results in more efficient truck weight-mile tax collection.

Personnel Productivity

The automatic storing of truck data in the SC from the WIM and static scales and automatically transferring these data daily to the ODOT mainframe has reduced the need for manual data entry. This reduction has freed the use of this person for other duties. PUC estimates monetary savings to be $10,000/year.

Safety Enforcement Enhancement

The vehicle safety files contain information on truck safety inspection. This enables the weighmasters and PUC safety personnel to know whether 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. These data are also used by safety auditors when performing on-premise investigations of a carrier's log books and after-the-fact safety audits.

Data Collection

Various ODOT functions have been and will be benefiting from improved truck weight data. Data from the WIM and static scales are now available on the ODOT mainframe for planning purposes, pavement design, research, traffic, and cost responsibility. In the past, these data were available but had to be processed manually and were costly to collect and access. Now they are available immediately on a daily and weekly basis. Also, data bases are being set up on truck freight commodities and weight.

Truck Productivity

The automated POE allows 50 percent of the trucks to bypass the static scales and PUC office, which minimizes time losses. Time

TABLE 5 Summary of Savings from Automation to State and Private Industry

Beneficiary	Source	Function	Annually $	5-Year Total $
A. STATE	Weighmaster	a. Automotation Crew Reduction (2)	78,200	391,000
		b. No Automation POE Expansion Postponement*	175,000	175,000
		Additonal Crew Need (3 for 1 yr)**	117,400	117,400
		Normal Crew (2 for 5 yrs)***	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****	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 b. Private Industry c. Total				$236,380 $286,300 $522,680

* Third scale and house, equipment, and lane installed in 1992 and in operation during 1993.

** Three additional crew members would be needed to run the third scale.

*** If there was no automation, the normal crew size would be 18, two more than for automation.

**** Truck operating costs are estimated to be $44 per hour. Only 50 percent of trucks would report to static scales.

savings are on the order of 60 to 120 sec/vehicle, which results in savings in operating costs of $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 5 min.

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

SUMMARY OF SAVINGS AND COSTS

Savings

The savings to the state and private industry from the WIM/AVI/SC automation system have been summarized in Table 5. Savings to the state are $470,300 annually and $1,181,900 for the 5 years of operation. Private industry savings are $286,300 annually, amounting to $1,431,500 during the 5-year period. Total annual savings, that is, state and private industry, amounted to $757,000 and $2,613,400 during the 5-year period. Average annual savings for the state, for private industry, and for both are $236,380, $286,300, and $522,680, respectively.

Costs

The costs for POE facilities and the automation system are given in Table 2. Table 6 presents the total costs of WIM/AVI/SC hardware and software (amounting to $362,000). Annual maintenance costs for WIM, hardware, and software are $8,200, amounting to $80,500 for the 5-year period. Average annual costs over the 5-year period amounted to $88,500.

LIMITS OF AUTOMATION

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

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 nonquantifiable benefits to ODOT, PUC, and the trucking industry. The result of this success has led to the automation of other ports, excluding the WIM sorter system.

On the basis of ODOT experiences with Woodburn, mainline sorting has been installed at the new Umatilla POE on I-82 SB and at the Wilbur and Booth Ranch weigh stations near Roseburg on I-5 SB and NB, respectively. These systems currently use variable message signs. The system at the Ashland POE on I-5 NB will use mainline sorting with a two-way communication AVI system to screen vehicles 5 mi from the port.

The success of the Woodburn port project has resulted in the development by the weighmasters of an integrated tactical enforcement network plan (*6*) using the electronic hardware and software principles. In addition, a strategic/business plan for a statewide IVHS-CVO system is in the making (*7*).

The complete success of the automation system at Woodburn SB POE and other ports will depend on all trucks carrying some kind of identification that can be automatically read. The limited number of transponders in the demonstration has shown that this system can work successfully. The WIM sorting system by itself has shown that

TABLE 6 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 port-of-entry are excluded (see Table 2).

it can successfully reduce truck volumes and improve POE truck movement as well as provide significant economic enhancements.

FUTURE RESEARCH NEEDS

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

1. Automated vehicle width, length, and 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 (*8*).
3. Driver identification. A means is needed to identify drivers of vehicles to ascertain compliance with driver qualifications and hour-of-service requirements.

REFERENCES

1. Krukar, M., and K. Evert. Weight Enforcement Strategies in Oregon from 1921 to 1990 and Beyond. *Proc., 40th Annual Road Builders' Clinic*, Moscow, Idaho, 1989.
2. Krukar, M. *The Oregon Weight-in-Motion/Automatic Vehicle Identification Demonstration Project. Final Report.* Highway Division, Oregon Department of Transportation, Salem, Sept. 1986.
3. Krukar, M. *Woodburn Southbound Port-of-Entry Automation Experimental Project. White Paper.* Planning Section, Highway Division, Oregon Department of Transportation, Salem, March 1986.
4. Krukar, M., and K. Evert. The Automation of the Woodburn Southbound Port-of-Entry on Interstate 5. *Proc., 3rd National Conference on Weigh-in-Motion: Applications and Future Directions.* St. Paul, Minn., Oct. 1988.
5. Rytter, D. A. *Functional Specifications for Woodburn Port-of-Entry Project.* Motorola Computer Systems, Inc., April 1987.
6. Krukar, M., and K. Evert. Integrated Tactical Enforcement Network (Automated Enforcement Facilities in Oregon). *Proc., National Traffic Data Acquisition Technologies Conference*, Austin, Tex., Aug. 1990.
7. *Strategic Plan for IVHS/CVO in Oregon.* Oregon Department of Transportation and Oregon Public Utilities Commission, July 1993.
8. Krukar, M., and K. Evert. Mainline Screening for Enforcement. *Proc., National Traffic Data Acquisition Conference*, Sacramento, Calif., Oct. 1992.

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