THE OREGON WEIGH-IN-MOTION/HEAVY VEHICLE ELECTRONIC LICENSE PLATE DEMONSTRATION PROJECT: NEW TECHNOLOGY FOR DATA COLLECTION.

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INTRODUCTION

For over a year, the Oregon Department of Transportation has been collecting weight and traffic data using weigh-in-motion (WIM) equipment, some interfaced with heavy vehicle electronic license plate (HELP) identification equipment. Both fixed-location and portable WIM's are being used. Todate this data has been mainly used for weight deterrent purposes although it is being used for road design, traffic planning, cost responsibility studies, and road taxation. This data is also being used by trucking firms for vehicle management purposes. The Oregon Department of Transportation is cooperating with the Federal Highway Administration in this project, which has been described by Krukar and Henion (1). The purpose of this paper is to (1) describe the Oregon experiment with HELP and WIM equipment, (2) present some preliminary results, (3) describe the present use of WIM/HELP data, (4) discuss future directions and uses.

THE OREGON AVI/WIM EXPERIENCE

(a) The Experiment

This experiment contains nine identifiable, but integrated elements and involves the automatic identification, tracking, classification, and weighing of trucks traversing U.S. Interstate Highway 5 northbound from the Oregon-California border to the Oregon-Washington border a distance of 310 miles. This also includes an automated port-of-entry at Woodburn on I-5 southbound. The nine elements are described below.

Element One:

A medium speed WIM and overheight sorting system has been installed at the Woodburn weight station. The WIM equipment, patented by International Road Dynamics (IRD) and distributed by CMI-Dynamics Inc. of Michigan, is fully interfaced with the station static scale. Only overloaded or overheight trucks are required to report to the static scale, others are signaled to return to the freeway without stopping. The station operator has a CRT which displays details of all violations, and also has the option of getting hard copy. The WIM scale computer is capable of storing a month's accumulation of data, but for statistical control purposes the data is transferred weekly to the IBM PC/AT at central headquarters. A detailed description of the IRD WIM scale has been published by the Road and Transportation Association of Canada (2). A similar system has been operating successfully in Alberta, Canada (3).

Element Two:

A high speed IRD WIM data collection system has been installed in both northbound lanes at the Jefferson exit, 28 miles south of Woodburn. A similar system is in use in the state of Minnesota. (4)

Element Three:

IRD automatic vehicle classifiers (AVC) have been installed in six lanes (north and southbound) at Hubbard, 9 miles north of Woodburn. These classifiers identify 19 vehicle configurations and provide information on vehicle speed and gap spacing. This is the first installation of this type of equipment in the U.S.

Element Four:

General Railway Signal (GRS) Heavy Vehicle Electronic Plate (HELP) system reader-activators have been installed at four locations along I-5. These reader-activators read data from precoded passive transponders (electronic license plates) mounted on trucks. This equipment has been described by Foote (5) and Armstrong (6). Twenty-one participating trucking firms have installed 200 transponders on their vehicles for this experiment. Two of the reader-activators are located at port-of-entry weigh stations at the north and south borders of the state and two are interfaced with the WIM computers at Jefferson and Woodburn. Trucks which have transponders are automatically tracked as they move through Oregon and overloaded trucks are identified while in motion. The data is temporarily stored on location and telemetered daily to the headquarters computer. From the central computer, participating firms are able to retrieve data on their trucks through a dial-up data transfer. A security system has been developed to prevent any firm from pirating information on another firm's trucks.

Element Five:

A portable Bridge Weighing System (BWS), which employs strain gauges to convert a bridge into a giant scale, weighs trucks as they pass over the bridge. The strain gauge data is converted to vehicle weight information by a computer housed in a van parked nearby. As the equipment is portable, it can be moved from bridge to bridge as desired. The theory and description of this system has been reported by Moses and Ghosn (7, 8), and the operation by Manch (9). The BWS WIM is used primarily on rural highways and is useful in determining which roads are used as bypass routes by overloaded trucks. The system also produces general weight and traffic data required by planners and road and bridge engineers.

Element Six:

A data base management system has been recently developed which ties all WIM and HELP data into a unified, accessable system. This system was developed at Oregon State University by Mohseni and Bell (10).

Element Seven:

Another HELP system, developed by Science Applications International Corporation (SAIC), has been interfaced with Bridge WIM to be used in rural locations. The purpose is to demonstrate that a completely portable HELP/WIM system is feasible using new HELP technology.

Element Eight:

A dynamic bridge formula compliance analyzer (DBFCA), developed by IRD and distributed by CMI-Dynamics, Inc. of Michigan, has been installed at the Ashland port-of-entry on I-5 northbound, 16 miles north of the California border. This port-of-entry is the busiest one in Oregon and the DBFCA will be used to help the weighmasters enforce the bridge formula.

Element Nine:

An IRD WIM sorter scale has been installed at the Woodburn southbound port-of-entry (POE) on I-5. This system will be tied into the HELP System and the Public Utility Commissioner (PUC) data base via a supervisory computer. The purpose is to automate this POE so that heavy vehicles with transponders will be able to by-pass the static scales and the PUC station provided they meet both weight, size and PUC requirements. About 85% of the 2000 daily truck traffic will be able to by-pass the scales. This will significantly reduce the weighmaster's work load. Trucks will also obtain time savings. The purposes, functions, benefits and costs are described by Krukar (11).

(b) Potential Benefits

Potential benefits emanating from the WIM/HELP projects are significant to both the state and the trucking industry, enabling them to monitor vehicles as they travel through Oregon. Among the potential benefits to industry are: reduced delays and increased productivity through more efficient scheduling of trucks and manpower; reduced illegal use of trucks by drivers to transport "hot loads"; and reduced theft of trucks and trailers. Benefits to the state may include: improved enforcement of vehicle weight laws; reduced audit costs and tax evasion through more efficient tracking of vehicles through the state; improved monitoring of hazardous material transport; and improved planning and development efforts through better commodity flow data. Improved weight and tax enforcement will benefit both state and industry. Enforcement officials point out that even through they estimate that over 90 percent of trucks using Oregon's highways are paying their proper road user taxes, and are within the legal weight limits, those who evade payment of taxes increase the financial burden to honest businesses. Increased audit and enforcement costs mean less money available for maintaining the roads. It is common knowledge that excessive weight, particularly axle weight, seriously compromises pavement life. Those who overload their vehicles create unnecessary maintenance needs and costs, again increasing the financial burden on the law-abiding majority. Further detail on potential benefits has been presented by Krukar and Henion (1), Krukar (12), and Burgess and Coulter (13).

(c) Operation

The project began on July 1, 1983. The selection and procurement of the WIM equipment took six months, installation another three months, and an additional month was needed for testing and debugging the system and software. The high speed WIM was in operation by February 14 and the data collection and telemetry has performed flawlessly. The medium speed sorter WIM commenced operation on March 9, but software problems did not allow for full operation until late April, when new program microchips were installed. The high speed classifiers began operating the first week in April, and again software problems were encountered and remedied with new micropchips. The BWS began operation by January 10, soon after the crew was trained by BWS engineers. Twenty-five bridges, located on rural highways in the northeastern part of the state, were instrumented for truck weighing during the project. Each selected bridge was individually calibrated. The HELP system was put into operation on July 23. Element 6 and 7 were operational by the end of April, 1985. Element 8 was operational in September 1985. Element 9 will be operational by January 1986 and automated by August 1986.

(d) Data Collection

Nineteen vehicle types (Figure 1) are being measured by the WIM and classifier equipment. Twelve tables of summarized data are telemetered weekly to the central computer. These tables are similar to those provided by the Minnesota DOT system (14, 15). Table 1 provides a listing of the WIM tables. The system also presents statistics on total vehicles measured, vehicles missing the scales, and other information. Additional tables showing violation of bridge formula, axle weight, and gross weight are being developed.

Table 2 shows the type of information obtained from the WIM interfaced with the HELP. The AVI equipment identifies the vehicles; the WIM obtains information on vehicle types, axle spacing, weight, speed and weight violations.

TABLE ONE

LIST OF WIM TABLES

1. Most Recent Vehicles with Transponders.
2. Weight Distribution and Average 18K ESAL by Vehicle Type.
3. Number of Truck Axles by Weight.
4. Front Axle Weights of 5-Axle Semi's (Type 11).
5. Vehicles with Highest Flexible 18K ESAL's.
6. Average Vehicle Length in Feet by Type.
7. Number of Vehicles and 18K ESAL by Day of Week (Lane 1).
8. Number of Vehicles and 18K ESAL by Day of Week (Lane 2).
9. Car and Single Unit Truck Volumes by Hour and Day of Week.
10. 5 Axle Semi's and other Truck Volumes by House and Day of Week.
11. Vehicle Volumes by Speed Range.
12. 5 Axle Semi's (Type 11) Flexible 18K ESAL.

The BWS WIM system presents data both in the actual form seen on the CRT screen and in 14 summary tables. These tables are listed in Table 3.

Consultants have developed data base formats and a management called the truck information retrieval (TIRS) system (16). A data base on HELP is being accumulated for this system. This data are sent to trucking firms involved with the HELP project for their information. Fourteen reports are available to the trucking firms, eleven on observations based on WIM/HELP stations on I-5 NB and three based on transponder vehicles. Four other reports are confidential and are not available to the trucking firms. Table 4 shows the report selection menu available to trucking firms.

TABLE TWO

HELP/WIM INFORMATION SUMMARY

Interstate 5, Jefferson Site, NB., MP 245.4
From: Monday, March 4, 08:05 To: Monday 20:58

DATE	TIME	VIOLATIONS	WEIGHT	SPEED	PUC	TRUCK	LANE
Mar 4	09:09	*	85.8	54	KJ99080	03600	1
Mar 4	09:46		72.3	57	KN72620	00440	1
Mar 4	10:47		81.6	54	KK76590	00250	1
Mar 4	10:53		30.1	55	KK76770	00450	1
Mar 4	11:08		64.4	53	KB69224	0132E	1
Mar 4	11:56		52.2	53	KB69534	0161E	1
Mar 4	14:13		107.9	57	KP11240	0005E	1
Mar 4	16:24	*	79.8	55	KD32210	00410	1
Mar 4	17.34		38.8	54	KN58910	0922E	1
Mar 4	18.54		56.5	54	KB69664	0167E	1
Mar 4	19:37	*	85.0	65	KJ99120	03650	2
Mar 4	20:58		48.4	60	KL14441	4025E	2

* This means that the vehicle is flagged for violations for gross weight, axle weight and/or bridge formula violation.

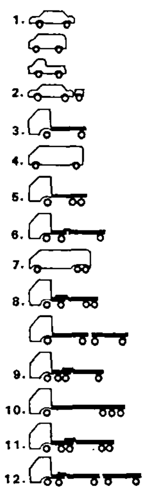
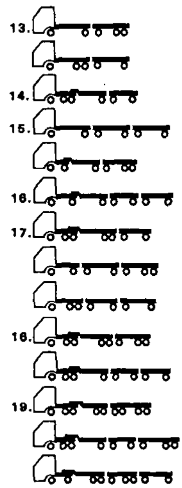
TABLE THREE

LIST OF BWS WIM TABLES

1. Gross Vehicle Weight (GVW) vs. Commodity and Vehicle Type.
2. Time vs. Commodity and Vehicle Type.
3. Time vs. GVW and Speed.
4. Average GVW vs. Time and Vehicle Type.
5. Distributions by Axle Weight and Axle Type.
6. Equivalent Single Axle Values (ESAL) vs. Vehicle Type and by Commodity.
7. ESAL's vs. GVW and Time
8. Violations per 1000 Trucks: Time vs. Commodity and Vehicle Type.
9. Violations per 1000 Trucks: GVW vs. Commodity and Vehicle Type.
10. Violations: Time vs. Commodity and Vehicle Type.
11. Violations: GVW vs. Commodity and Vehicle Type.
12. Violations: Overweight in Kips vs. Commodity and Vehicle Type.
13. Violations: Commodity vs. Vehicle Type.
14. Commodity vs. Vehicle Type.

FIGURE 1

CLASSIFICATIONS USED IN OREGON'S WEIGH – IN – MOTION STUDY

Vehicle Type		Vehicle Type	
1.	Cars	13.	Other 5 axle Comb. (2-3)
	Panels		(3-2)
	Pickups	14.	6 axle Comb. (3-S1-2)
2.	Light Vehicles w/trailers	15.	(2-2-2)
3.	2 axle, Single Units		(2-S1-3)
4.	2 axle Buses	16.	Triples (2-S1-2-2)
5.	3 axle Single Units	17.	Other 7 axle Comb. (3-S2-2)
6.	3 axle Combinations (2-S1)		(2-2-3)
7.	3 axle Buses		(1-2-2)
8.	4 axle Combinations (2-S2)	18.	8 axle Comb. (3-S2-3)
	(2-2)		(3-S1-2-2)
9.	(3-S1)	19.	9 axle or more Comb. (3-S2-4)
10.	4 axle Single Units		(3-S1-2-3)
11.	5 axle Semis (3-S2)		(2-S2-3-2)
12.	5 axle Twins (2-S1O2)		

These are examples of configurations; there are other possible combinations not illustrated.

PRELIMINARY RESULTS

(a) General

The results must be considered preliminary, since data analysis is just beginning. The system has been in operation long enough to provide some conclusive detailed results.

(b) Reliability and Ruggedness

Eighty percent of the vehicles crossing the Jefferson WIM scale are being weighed and recorded; 20 percent are missing the scale, either by error or design. By the end of October over 10.0 million vehicles had been weighed with minimal equipment downtime, due primarily to power outages. The classifiers at Hubbard and the Woodburn sorter scale recorded about 2 percent and 25 percent of the vehicles missing the scales, respectively. However, these sites experienced significant downtime due to the software problems previously mentioned. The Bridge WIM has performed very well with two exceptions. Difficulty was encountered in getting the tape switches used for classifying vehicles to adhere to wet pavement surfaces. There have also been software problems which have caused significant delay in data collection and analysis.

TABLE FOUR

REPORT SELECTION MENU
Available to Trucking Firms [1]

A. FAI-5 HELP Observation

1 --	Observations by	Date & Time
2 --		Date & Location
3 --		Date & Help [2] No.
4 --		Date & Unit No.
5 --	Observations by	Location & Date
6 --		Location & HELP No.
7 --		Location & Unit No.
8 --	Observations by	HELP No. & Date
9 --		HELP No. & Location
10 --	Observations by	Unit No. & Date
11 --		Unit No. & Location

B. Transponder Vehicles

21 --	List by	HELP No.
22 --		Company Unit No.
23 --		Auth. & Comb. Wts.

[1]There are four other reports which are confidential and are not available to the trucking firms.

[2]HELP stands for heavy-vehicle electronic license plate.

TABLE FIVE

STATIC SCALE AND WIM WEIGHT COMPARISONS - FIVE AXLE SEMI'S ONLY [1]

AVERAGE WEIGHT IN POUNDS	STEERING AXLE	FIRST TANDEM AXLE	SECOND TANDEM AXLE	GROSS VEHICLE WEIGHT
Static Scale	10,753	30,624	30,324	71,701
Woodburn WIM	10,555	31,955	31,362	73,872
Jefferson WIM [2]	10,319	31,908	31,432	73,659
PERCENT DEVIATION				
Woodburn WIM to Static Scale	-1.84	+4.35	+3.42	+3.03
Jefferson WIM to Static Scale	-4.04	+4.20	+3.65	+2.73
Jefferson WIM to Woodburn WIM	-2.24	-0.15	+0.22	-0.29

1 A sample of 37 five axle semi's.
2 Average weights from both lanes.

The HELP system has worked very well under all environmental conditions. Some electronic problems have occurred with the readers at the Ashland and Ridgefield, Washington POE's. These were rapidly corrected. The average daily number of trucks with transponders being picked up by the AVI readers at Ashland, Jefferson and Ridgefield are 15, 30, and 10, respectively. The number of vehicles with transponders being picked up at the Woodburn weigh station varies with the number of hours Woodburn is open. Monthly data at Ashland shows that the error in transponder readings is less than 0.6 percent.

(c) Accuracy

Calibration tests were run using five axle semi-trucks to check the accuracy of the WIM scales at Jefferson and Woodburn against the Woodburn static scales. The results are shown in Table 5. Although the sample size is small, the results show the WIM scales to be quite accurate. WIM vehicle speed readings were checked against a radar gun. They were found to be about 10 percent high and were adjusted. Bridge WIM measurements were compared with a static scale. Gross weights were within five percent of the static scale weights but axle weights showed a 10 percent variance. Periodic weight and speed accuracy checks are scheduled to be conducted throughout the life of the experiment.

It should be noted that the term accuracy used here is a misnomer as dynamic weight is compared to static weight. This comparison is not valid because dynamic weight is a combination of vehicle weight, speed, vehicle frequency, truck suspension systems, road condition and other variables. Dynamic weight can be higher or lower than the static weight which is the dead weight of the vehicle and load.

Weight comparisons between static scales and the Bridge WIM are even more difficult. The bridge itself is a big factor and results can be affected by the type of bridge, span length, skew, bridge approach condition, deck condition, vehicle speed, number of lanes, and traffic conditions. This makes comparisons between static scales and Bridge WIM very difficult as gross weight differences can vary between ±2% and ±10%, and axle weight differences can vary between ±5% and ±20%. These large variations between bridges may make the data suspect.

(d) Traffic Data

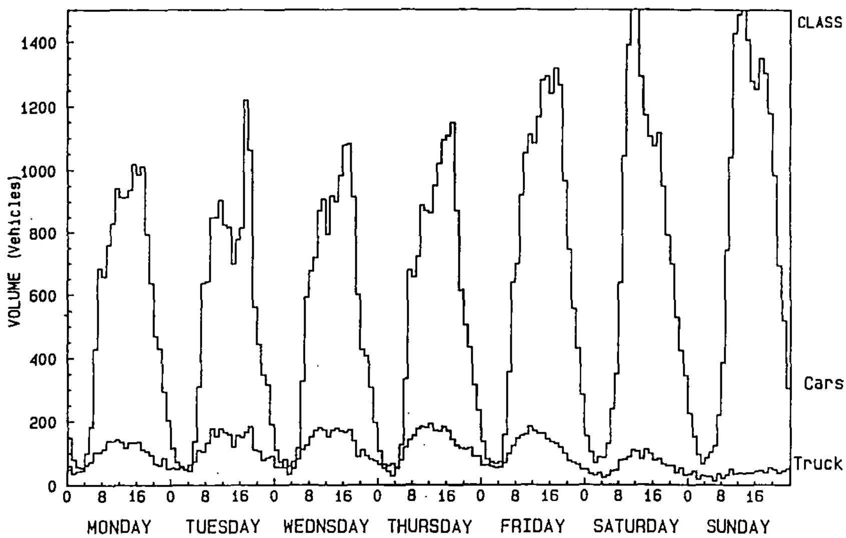
Some examples of the types of traffic data obtained and manipulated from the Jefferson WIM are tabulated in Tables 6 and 7 and shown in Figures 2 to 8.

Data from the Jefferson WIM and the Hubbard classifiers show that very few drivers obey the 55 mile per hour speed limit. The average speed is about 60 mph with passenger vehicles travelling slightly faster than trucks. Other speed monitoring programs confirm these results.

Table 6 and Figures 2, 3, and 4 show that truck traffic starts to increase late on Sunday afternoon, reaches a peak by Thursday and decreases throughout the weekend. As previous manual counting has been conducted on a weekday only basis, this information has been valuable to Oregon's traffic engineers. Also truck volumes drop drastically during holidays. Table 7 and Figure 5 and 6 show that 5 axle semi's (type 11) are the most frequent truck types and produce the most equivalent single axle loads

FIGURE 2

HOURLY VEHICLE VOLUME BY CLASS



FICURE 3

OREGON WIM - JEFFERSON SITE

VEHICLES EACH DAY

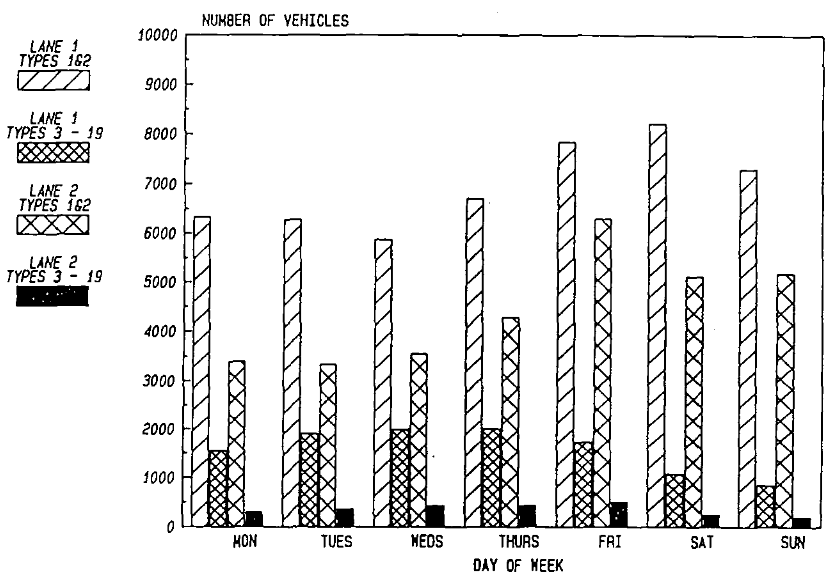
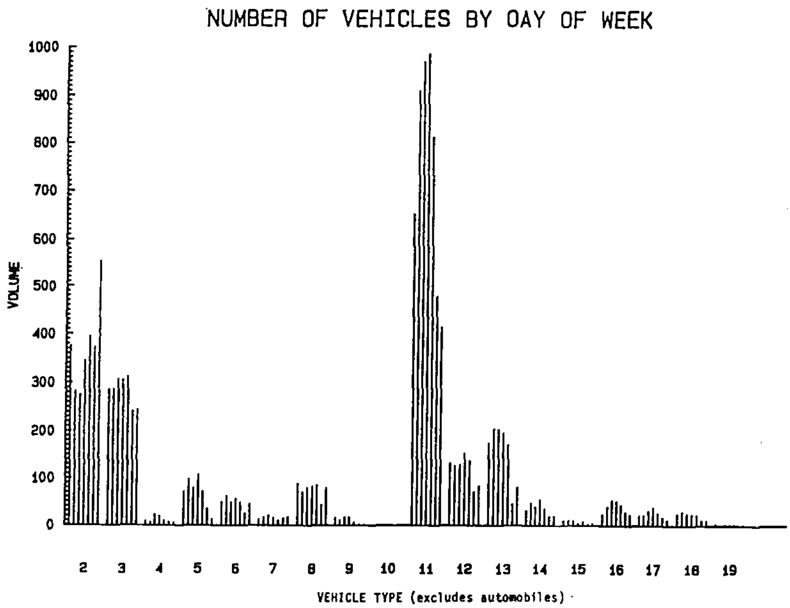


FIGURE 4



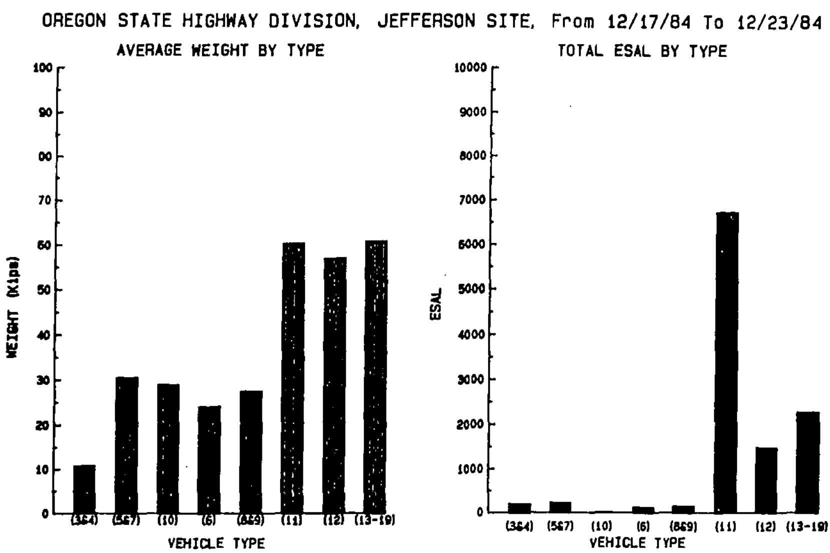


FIGURE 5 AVERAGE WEIGHT AND TOTAL ESAL BY VEHICLE TYPE

FIGURE 6 OREGON WIM - JEFFERSON 11/5/84

TOTAL DAILY ESAL BY LANE

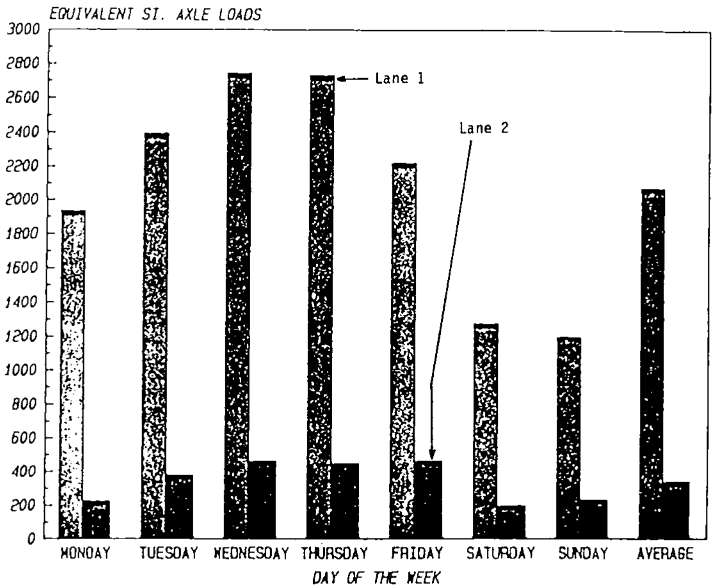


FIGURE 7 OREGON WIM - JEFFERSON SITE

WEEKLY TRUCK VOLUME

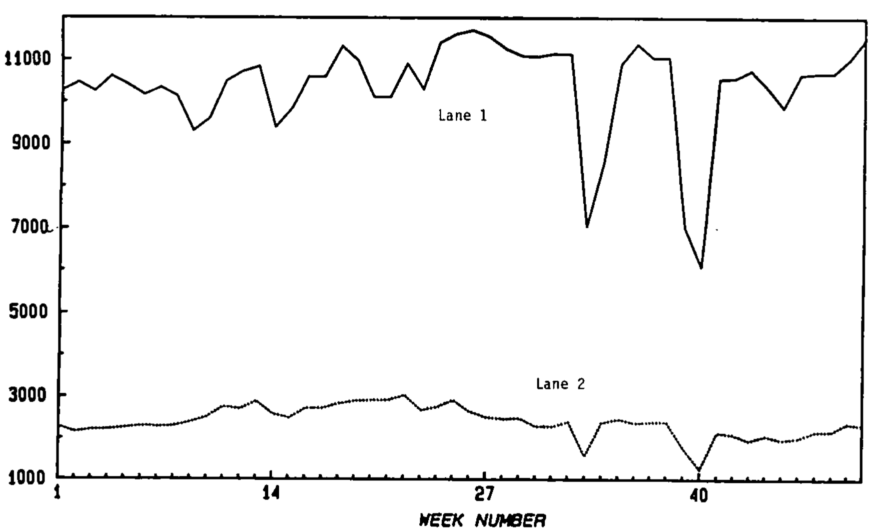
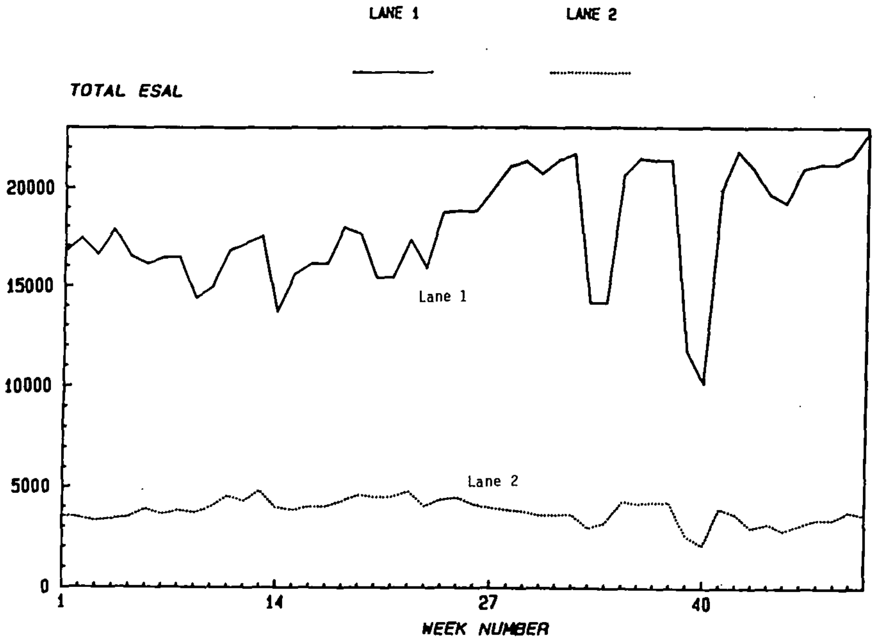


FIGURE 8 OREGON WIM - JEFFERSON SITE

WEEKLY ESAL (1/4/84 TO 24/3/85)



(ESALS). Figure 5 also shows that heaviest group of trucks are 5-axle semi's (type 11) with an average gross weight of 61,000 pounds and truck types 13-19 with average gross weight of 62,000 pounds. Over 64 percent of the traffic is in lane 1. Figures 7 and 8 show the truck and ESAL volumes over the year. Both show that the truck traffic and ESALS are slowly increasing. Some seasonal trends appear to be discernable on I-5. This is also true for other roads where truck traffic is highly seasonable.

Data from the Jefferson WIM show that more than 12 percent of the trucks with five or more axles exceed 80,000 pounds. This does not mean that 12 percent are violating the law as many vehicles operate under special permit to carry excess weight. Table 8 is a special table showing the twenty worst vehicles with the highest ESAL's on flexible pavement. Some of the ESAL impacts are larger then expected. Although these truck weights exceed Oregon's weight limits, some of these vehicles may be operating under extended weight permits. This table shows that there are vehicles which are imposing large ESAL's on our highways. This may indicate that equivalent single axle loads (ESAL) are accumulating faster than anticipated in pavement design. If this is true then our highways are wearing out at a faster rate than originally predicted. This has important implications for highway maintenance, highway and bridge design.

TABLE 6

JEFFERSON WIM SITE - OREGON DOT

SUMMARY OF DAILY TRAFFIC, BOTH LANES -From Monday 12/24/84 to Sunday 12/30/84

	TYPES 1 & 2		TRUCK DATA							
			TYPES 3- 19				TYPE 11			
DAY	VOLUME LANE 1	VOLUME LANE 2	VOLUME LANE 1	VOLUME LANE 2	ESAL LANE 1	ESAL LANE 2	VOLUME LANE 1	VOLUME LANE 2	ESAL LANE 1	ESAL LANE 2
MONDAY	8942	4200	746	146	537	72	270	46	281	47
TUESDAY	9936	5810	426	114	342	69	141	30	214	45
WEDNESDAY	9862	5942	1464	307	1606	348	600	100	822	150
THURSDAY	8888	5356	1917	400	2432	373	844	168	1300	244
FRIDAY	8973	5507	1828	426	2231	433	840	190	1234	283
SATURDAY	8614	4487	1197	264	1493	308	538	136	914	233
SUNDAY	6918	3831	785	179	982	171	384	83	626	128
TOTAL	62133	35132	8363	1838	9623	1774	3617	754	5392	1130
AVERAGE	8876	5019	1195	263	1375	253	517	108	770	161

SUMMARY OF DATA FOR BOTH LANES:

	VOLUMES	PERCENTS	ESAL	PERCENTS
ALL TRUCKS	10201	9.5	11397	100
TYPE 11 TRUCKS	4371	4.1	6521	57
ALL VEHICLES	107466	100.0	11397	100

PROJECTED YEARLY TOTALS:

VOLUMES	ESAL
530446	592634
227291	339112
5588209	592634

TABLE 7 JEFFERSON WIM SITE - OREGON DOT

WEEKLY TRUCK DISTRIBUTION BY TYPE - From Monday 12/24/84 To Sunday 12/30/84

TYPE	DESCRIPTION	NO. OF VEHICLES	PERCENT VEHICLES	AVERAGE ESAL	TOTAL ESAL
TYPE 1	CARS	96289	89.6	0.00	0.00
TYPE 2	CARS+TRAILERS	976	.9	0.00	0.00
TYPES 3&4	RIGID 2 AXLE	2673	2.5	.07	189.39
TYPES 5&7	RIGID 3 AXLE	499	.5	.62	311.27
TYPE 10	RIGID 4 AXLE	0	0.0	0.00	0.00
TYPE 6	SEMI 3 AXLE	250	.2	.42	105.64
TYPES 8&9	SEMI 4 AXLE	443	.4	.39	171.33
TYPE 11	SEMI 5 AXLE	4371	4.1	1.49	6521.39
TYPE 12	TWIN 5 AXLE	675	.6	2.37	1601.13
TYPES 13-19	OTHER	1289	1.2	1.94	2496.45
TYPES 3-19	TOTAL (TRUCKS):	10201	9.5	1.12	11396.80
TYPES 1-19	TOTAL (ALL):	107466	100.0	.11	11396.80

(e) Enforcement Potential

At this time WIM by itself cannot be used for enforcement. WIM can be used for sorting and for scheduling of enforcement personnel and programs. WIM can be used to indicate how much violation of weight laws is occurring. Comparison of truck volume and weights at Woodburn and Jefferson indicate that bypassing of the weigh station scales is occurring.

The results from these comparisons show that there is a 3.5 percent increase in vehicles deliberately missing the Jefferson WIM scales when the Woodburn weigh station is open and that apparent violations decrease by 2.2 percent. This is shown in Table 9. The results in Table 10 also show that about 13 percent of heavy vehicles are bypassing the Woodburn weigh scales and that by the time the trucks reach Woodburn, the apparent violations decrease by 45 percent. It shouldbe noted that actual violations are about 5.9 percent less than apparent violations.

TABLE EIGHT

THE WORST TWENTY VEHICLES WITH HIGHEST FLEXIBLE 18-K BY RANK
(March 1984 - February 1985)

Type	Lane	Day	Time	Axle (or Axle Group Weights 1st	2nd	3rd	4th	5th	6th	Axle Configrt'n	Gross Weight	Speed	18K - ESAL Rigid	Flexible
18	1	March 29	18:13	9.0	29.9	23.9	23.4	24.0	16.5	1211111	144.3	53	12.52	11.14
13	1	March 21	9:39	11.0	52.3	22.6	23.9			1211	109.8	54	16.40	11.07
12	1	Oct 18	7:52	9.2	21.8	24.5	22.7	23.4		11111	101.6	58	11.76	10.73
12	1	Oct 9	5:43	10.1	22.8	24.2	21.2	23.9		11111	102.2	58	11.66	10.65
12	1	Oct 13	17:17	9.7	23.8	22.7	23.3	22.2		11111	101.7	69	11.47	10.50
14	2	Sept 20	8:46	7.7	33.0	29.4	19.8	18.7		12111	108.6	57	12.13	10.14
16	1	June 30	21:47	8.7	26.9	23.5	18.3	15.9	16.7	1111111	120.9	55	11.09	10.12
12	1	Oct 9	9:01	9.4	22.2	23.6	22.2	23.0		11111	100.4	61	10.96	10.07
12	2	Aug 24	8:27	9.5	21.9	22.2	24.2	22.6		11111	100.4	56	10.95	10.06
12	1	Oct 10	18:33	10.5	24.0	22.6	21.3	22.7		11111	101.1	60	10.88	10.00
14	1	Aug 1	00:20	7.6	26.6	26.1	21.7	24.2		12111	106.2	52	11.18	9.80
12	1	March 12	9:59	9.8	21.6	20.7	23.4	24.2		11111	99.7	58	10.65	9.79
12	2	Sept 1	17:05	8.5	24.1	20.8	22.7	22.5		11111	98.6	64	10.64	9.78
14	2	May 24	9:06	10.9	26.0	25.3	23.8	22.8		12111	108.8	62	10.96	9.68
14	1	Sept 8	3:19	9.2	29.1	23.7	24.5	23.4		12111	109.9	51	11.02	9.63
12	1	Oct 16	9:07	8.7	21.0	23.7	22.3	22.6		11111	98.3	56	10.35	9.54
13	2	June 27	6:14	10.0	36.7	23.8	27.4			1211	97.9	62	11.79	9.53
11	1	Oct 16	1:21	10.5	45.6	53.8				122	109.9	57	17.63	9.52
12	1	Oct 13	14:40	9.2	22.0	22.9	21.5	23.2		11111	98.8	60	10.30	9.51
12	1	March 9	15:41	9.4	22.0	22.3	23.3	22.1		11111	99.1	60	10.29	9.51

Preliminary Bridge WIM results show that truck loads are higher than previously thought, particularly at night, which has implications for adjusting weight enforcement programs. Table 11 shows that the apparent violations on some highways outside the interstate system exceed 20 percent. These violations are apparent because close examination of the data shows that some weight readings are due to vehicle type, e.g., chip trucks. The rear axles are reading high which maybe due to the rear air suspension system. The type of bridges and traffic volumes also affect the readings. Comparisons with static and portable scales can reduce these apparent violations by as much as 15 percent. The results also show these violations are mainly local, such as gravel and log trucks going to and from nearby sites. It is obvious that the Bridge WIM cannot be used by itself for enforcement purposes.

Tests by consultants have been recently concluded on interfacing the Bridge WIM system with AVI. The purpose was to develop a portable WIM/AVI system. The results in the consultant's report (16) show that this concept is feasible and technologically practical.

TABLE NINE

IMPACT ON TRUCK TRAFFIC AT JEFFERSON WIM
WITH WOODBURN WIM SORTER OPEN

WOODBURN	PERCENT NOT WEIGHED	PERCENT WEIGHED	PERCENT APPARENT VIOLATIONS
Open	15.7	84.2	16.4*
Closed	12.3	87.7	18.7
Impact	+3.5	-3.5	-2.2

* Cited violations are 5.8 percent less than apparent violations.

TABLE TEN

TRUCK VOLUMES AND VIOLATIONS
AT JEFFERSON WIM AND WOODBURN WIM SORTER

SCALES	WEIGHED	NUMBER	APPARENT VIOLATIONS PERCENT
Woodburn	3,914	341	10.8
Jefferson	4,505	624	16.4
Differences	-591	-285	
%	-13.1	-45.5	-5.6

TABLE ELEVEN

APPARENT VIOLATIONS AT SELECTED HIGHWAYS
WITH BRIDGE WIM - PRELIMINARY RESULTS

Highway	Location	Average Violations - % Apparent	Probable*
18	Muddy Creek	33.0	18.5
22	Gooseneck Creek	40.9	21.1
34	Eckman Slough	19.8	4.9
42	Looking Glass	24.1	13.8
99E	Battle Creek	8.6	5.6
99W	Lukiamute	21.1	11.7
211	Pudding River	32.6	21.1
219	Newberg	27.9	14.5
County	Stayton-Scio	21.1	8.B

* A ten percent and five percent leeway for axle and gross vehicle weights, respectively was used to establish probable violations whenever it was not possible to check weights using portable or static scales.

THE USES OF WIM/AVI DATA

(a) Data from I-5 WIMs

WIM data from the two sites have been utilized by the weighmaster unit, planning section, the road design unit, the traffic section and the research section. The weighmasters have used this data to evaluate violation rates and for scheduling purposes. Several units with the planning section have used the data for urban studies and for cost responsibility studies. Road design has used the ESAL data. Their comment has been that the ESAL values are higher than the ones being used currently. The traffic section has used the data to check speeds and correct their truck volumes. The research section has used the data for some of their pavement research projects.

(b) Automatic Vehicle Classifier (AVC) Data

This data is being used by the traffic section, road design unit, planning and research sections. The traffic section is using this data as an addition to the data from the automatic traffic recorders. Road design is using the data for ESAL values and traffic split in the 6 lanes. The planning section is using this data for urban studies. Research is using this AVC data for overlay studies.

(c) WIM/HELP Data

This data is collected on a daily and weekly basis and is being sent to the twenty-one participating trucking firms. The use depends upon the individual trucking firms; most of the trucking firms are using the data for Oregon weight-distance tax backup and for monitoring their vehicles. A data base management system has being set-up and the trucking firms are able to select a variety of menus as shown in Table 4. The Public Utility Commissioner (PUC) would like to use this data for weight-distance tax audit purposes. The limited amount of transponders plus promises to the participating trucking firms that this data at present will not be used by the state for tax audit purposes has limited this important use. The weighmasters would like to use this data for enforcement and deterrent purposes but are held back by similar reasons plus the Oregon weight enforcement laws.

(d) Bridge WIM Data

The Bridge WIM was orginally going to be used for gathering data for planning and traffic purposes. This purpose was side-tracked when the Bridge Section asked for help in monitoring truck traffic on a major deteriorating bridge on Pacific Coast Highway 101. This bridge is the Alsea Bridge at Walport. This is a concrete arch bridge built some 50 years ago, a landmark which is now showing pier foundation problems and Portland cement concrete deterioration due to chlorides from the salt water and air. This bridge is scheduled for replacement in six years but there is concern about its rapidly deteriorating condition and safety. Economic hardship would occur to the communities if this bridge should collapse since the nearest detour is over 67 miles long. The Bridge Section asked the weighmasters to monitor the truck traffic and weight using the Bridge WIM. Problems occurred with using the strain gages on the Alsea bridge PCC beams. The strain gages would not stay attached due to the poor condition of the concrete. A bridge several miles away had to be used. Results showed that there were overloaded trucks using the bridge. It was decided to post weight limits and build portable scale pits at the SB and NB entrances. The Bridge WIM has been used in conjunction with the portable scales and by itself to monitor the truck traffic. The results have been gratifying as the number of overloaded trucks using the bridge have dropped to zero. Overloaded trucks with legal permits are permitted to cross the bridge alone with other traffic being stopped. Local publicity also helped the situation. The Bridge WIM is being successfully used here as a deterrent.

The Bridge WIM is also being used to collect data on roads outside the interstate system. The data is for scheduling of portable scales set-ups and static scale weigh station crews. In some areas, the Bridge WIM has been used as a sorter by sending overloaded trucks to portable scales and weigh stations.

The Bridge WIM will be used in the future for truck weight studies, highway pavement monitoring system studies, cost responsibility studies, and traffic studies. The weighmasters will continue to use the Bridge WIM as a deterrent on some highways.

FUTURE DIRECTIONS

The future of HELP/WIM Oregon will largely be determined by the outcome of this demonstration project. To date the results look encouraging. The Oregon State Highway Division is considering a three-tier hierarchy of WIM (based on cost and road type). The plan involves WIM scales at selected locations on the most heavily travelled roads to develop travel characteristics for use with data obtained from the other two equipment types, classifiers and traffic loops. The Bridge WIM will be employed to develop traffic characteristics on rural roads to augment classifier and loop date.

If the automation of the Woodburn POE proves to be successful, all the other five POE's will be similarly automated. The outcome also depends upon the findings from the Crescent Project.

HELP will be used to identify and track vehicles for both enforcement and private business purposes. HELP data is useful to both the state for audit and tax purposes, and to trucking firms attempting to increase productivity and reduce costs.

The interest in HELP systems, integrated with automatic vehicle classifiers (AVC) and/or WIM, is so great that a group of western states and Canadian provinces have embarked upon a multi-jurisdictional project to demonstrate the utility of an integrated electronic traffic monitoring system. Initial progress has been made in organization, funding, and work program development. This has become known as the Crescent Demonstration Project (17). Alaska, Texas, New Mexico, Nevada, Arizona, California, Oregon, Idaho, Washington and British Columbia are members of this project. Several HELP systems will be field tested. Some of the HELP systems will be standing alone while others will be integrated with WIM and AVC. This project will help select the best AVI system and demonstrate its utility.

This HELP/WIM demonstration and the Crescent Project will provide the information needed to develop a reality in which both the public and private sectors will benefit.

Conclusion

Data collection in the past has been a hit and miss operation requiring periodic expensive manual counts. Frequently the data was unreliable, expensive, and untimely. The WIM/HELP system looks very promising. Despite high initial capital costs, the WIM/HELP does provide quality and quantity traffic data with truck weights. With the Strategic Highway Research Program coming onboard with its Long-Term Pavement Performance Monitoring of 4000 highway sections, the revised Traffic Monitoring Program within the Highway Planning and Research Program, and Federal emphasis on Truck Size and Weigh Enforcement certification requirements, the only practical and economical way to obtain this data will be through new technology such as the WIM/HELP system being demonstrated in Oregon.

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