Table 1. Number of urban freeway guide-sign panels with concurrent route signing.

Inventory Location	Number of Guide-Sign Panels						
	Interstate-Interstate	Interstate-U.S.	U.S.-U.S.	Interstate-State	U.S.-State	None[a]	Total
Out of state							
Atlanta	20	0	1	0	0	57	78
Chicago	44	0	15	3	4	104	170
Denver	6	1	4	0	4	77	92
Kansas City	11	72	9	0	0	116	208
Los Angeles	3	0	0	0	0	159	162
New Orleans	0	0	0	0	0	64	64
Subtotal	84	73	29	3	8	577	774
Texas							
Dallas	23	93	1	0	0	105	222
Fort Worth	0	69	19	0	6	75	169
Houston	0	95	0	0	9	89	193
San Antonio	4	135	5	2	0	105	251
Subtotal	27	392	25	2	15	374	835
Total	111	465	54	5	23	951	1609

[a]None = one route number (no concurrent signing).

5. Texas stands almost alone in the continued use of redundant concurrent signing of an Interstate freeway with U.S. route numbers.

6. There are a few signing locations in Texas where the combination of a large number of concurrently signed intersecting routes are combined with a high-speed, large, multilane freeway facility, which results in signing plans that are likely to surprise and overload out-of-state motorists who are unfamiliar with them.

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Traffic Control and Geometrics for Weigh-in-Motion Enforcement Stations

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A discussion of geometric design concepts for weigh-in-motion (WIM) enforcement stations is presented. In-motion weighing techniques for trucks have been developed in recent years by which estimates of static axle weights can be made reliable to within 10 percent for trucks running at speeds of 60 km/h (37 miles/h) and perhaps higher and within about 2 percent for trucks running at speeds of 20 km/h (12 miles/h) or lower. High-speed weighing can be used to screen out only the suspected weight-limit violators and allow the obviously legally loaded trucks to pass without stopping and waiting to be weighed. Suspects can be checked for actual violation by a low-speed WIM system at rates up to 10 trucks/min without stopping or by static scales at perhaps 20 trucks/h with stopping required. A number of WIM enforcement-station layouts are possible. Two configurations are suggested. A recommended system of signs, pavement markings, and traffic-control signals that will guide the driver smoothly through the WIM enforcement station at reduced speed, but without stopping, is presented. It is concluded that weight-enforcement operations can be accomplished safely, efficiently, conveniently, and economically with properly designed WIM equipment, weigh stations, and traffic-control systems.

The current energy situation and rising economic pressures have, in recent years, fostered demands for increases in commercial vehicle sizes and weights. The resulting use of larger, heavier trucks is causing planners, engineers, economists, and enforcement personnel to realize the importance of having adequate, current information on truck size and weight available. Such data have historically been collected by stopping trucks at weigh stations or at the roadside for weighing and measurement. Both the quantity and the quality of the data obtained by this method have generally been somewhat limited, mostly because of the very high user and collection-agency costs associated with vehicle deceleration, waiting, and acceleration maneuvers required for static weighing. Site-construction costs and safety have also been considerations.

Electronic in-motion weighing equipment is now available to supplement or replace static weighing devices. Such equipment makes it possible to collect the needed vehicle weight and dimension data without requiring trucks to stop. Eight states are currently using in-motion weighing systems for enforcement purposes, weight surveys, or both (1). The geometric configuration of the weighing sites and the provisions for traffic control range from simple installation of in-motion weighing equipment in the main lanes of highways with no traffic control to rather elaborate off-road enforcement stations with traffic-control signs, markings, and signals. For a variety of reasons, the concept of the off-road weigh station has generally been found to be most appropriate where enforcement is a primary function.

The geometric design of an off-road weigh-in-motion (WIM) enforcement and/or survey station is highly dependent on site conditions and intended function. Although some standardization of the geometrics of such facilities is appropriate, traffic-control concepts need to be standardized as soon as possible so that safety, efficiency, and economy can be realized in the early years of implementing the WIM concept. Experience with the operation of WIM enforcement stations to date has indicated that traffic control is a problematic feature.

This paper presents a recommended design concept for WIM enforcement sites. The geometric features presented exemplify potential design concepts, but the suggested traffic-control concepts are more rigorously developed on the premise that the truck drivers who pass through the weigh station must be provided with the required information at the right time if they are to respond properly.

CONCEPTS OF IN-MOTION WEIGHING OF VEHICLES

The dynamic behavior of a truck wheel traveling over an irregular pavement surface is a very complex physical phenomenon. Force applied to the road surface at a particular instant by the tires of a moving truck can vary from zero when the tire bounces off the road to as much as twice the static weight. All in-motion weighing techniques use a sample of this continually varying dynamic tire force as an estimate of the static wheel force or weight. Under ideal conditions, there is no vertical acceleration of the truck, and therefore dynamic force exactly equals static force. Such ideal conditions never exist in the real world due to the effects of air flow over the vehicle, irregularities in the pavement surface, and imperfections in vehicle wheels and suspension systems.

Despite the complex problems associated with estimating static vehicle weights from dynamic force measurements, accuracies in the range of 10-12 percent with confidence levels of 80-90 percent are attainable for vehicles moving at high speed. Much greater accuracy is feasible at low speed.

In addition to producing estimates of static wheel weights from dynamic force measurements, WIM systems can provide additional traffic survey information. Inductance loop detectors installed adjacent to the in-motion force-sensing device can produce measures of vehicle speed and vehicle length, and measurements of time between force pulses can give measures of axle spacing. This information can be combined to yield a classification of each vehicle surveyed by the system. Practically attainable levels of accuracy and statistical confidence levels for each of the commonly obtained items of truck-traffic survey data are given in Table 1.

Table 1. Accuracy attainable in truck-traffic surveys by use of WIM systems.

	High-Speed WIM[a]		Low-Speed WIM[b]	
Measured Parameter	Accuracy	Level of Confidence (%)	Accuracy	Level of Confidence (%)
Vehicle speed	±2 km/h	95	±1 km/h	95
Weight of single axle	±10 percent	90	±2 percent	99
Weight of axle group	±10 percent	90	±2 percent	99
Total weight of vehicle	±10 percent	90	±2 percent	99
Spacing between axles	±0.1 m	95	±0.1 m	95
Wheelbase of vehicle	±0.2 m	90	±0.2 m	90

Note: 1 m = 3.3 ft, and 1 km = 0.62 mile.
[a]Speed < 60 km/h.
[b]Speed < 15 km/h.

IN-MOTION WEIGHING FOR ENFORCEMENT PURPOSES

Data on vehicle size and weight are usually collected for two related but somewhat different purposes. Statistical survey data are normally used for highway planning, design, and maintenance, whereas specific data about a particular vehicle are required for the enforcement of vehicle size and weight regulations. In nonenforcement applications, stochastically developed statements about the population of trucks, or selected strata of this population, are desired. Variability in weight measurements may be effectively managed by increasing sample sizes. For enforcement applications, however, variability is a significant problem.

Therefore, if in-motion weighing is used for enforcement purposes, requirements for reduced variability must be met through a combination of high-speed and low-speed weighing. Use of such a two-stage process might consist of installing a WIM system in or near the regularly traveled way in order to sort vehicles into those that are suspected of exceeding weight regulations and those that are obviously legally loaded. That portion of the traffic stream that is suspect may then be forced to decelerate and be weighed again under less variable low-speed conditions.

In such a two-stage weighing arrangement, only those vehicles that approach or exceed legal weight limits would be required to decelerate greatly below desired speeds. Only those vehicles that actually exceed legal limits would be required to stop and await legal action.

Under current state laws, WIM devices are not legally certified for enforcement applications. National Bureau of Standards Handbook 44 (2) states acceptance and maintenance tolerances for axle-load scales as 0.1 and 0.2 percent of applied load. However, 18 states currently have statutory tolerances that range from 2 to 10 percent of legal limits for axle weights. Such tolerances are established to account for the possible inaccuracies of weighing devices (1).

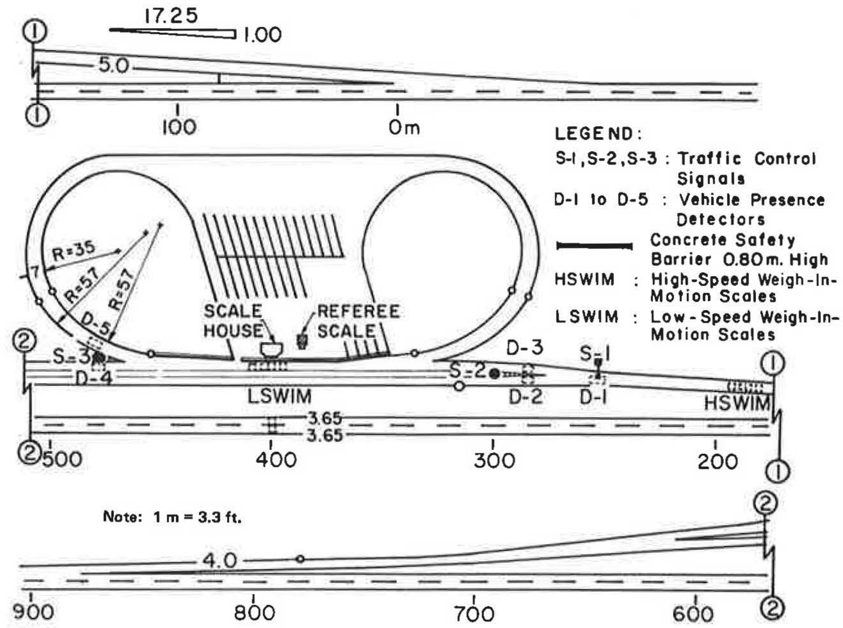
As noted previously, vehicle speed affects the variability (or accuracy) of static weight estimates obtained by using WIM devices. Manufacturers of in-motion equipment, however, indicate that, if vehicle speeds are 16 km/h (10 miles/h) or less, dynamic weights within 1 percent of static weights are easily attained (1).

Legislative action by the states will probably provide certification of in-motion equipment in the near future. Due to the nature of the interaction between vehicle speed and accuracy, certification will probably be provided for low-speed (less than about 16 km/h) weighing. Assuming that this does occur, the stage will be set for use of in-motion equipment in a high-speed-sort, low-speed-weighing mode.

GEOMETRIC DESIGN FEATURES OF WIM STATIONS

Use of WIM devices for vehicle weight enforcement will require geometric and associated traffic-control features that enable efficiency and encourage

Figure 1. Suggested configuration for vehicle-weight-enforcement station.



operational safety. Conceptual geometric features of a permanent WIM enforcement station are shown in Figure 1. This facility provides a deceleration lane in which trucks can decelerate prior to initial weighing at the high-speed weigh-in-motion (HSWIM) scale. Speeds for high-speed weighing should desirably be less than about 60 km/h (37 miles/h) in order to provide the accuracy noted in the high-speed portion of Table 1. All truck traffic will be channeled over the HSWIM system. This system will identify each truck as legally loaded or suspected of being overweight. Marginal or overweight vehicles will be sent to the low-speed weigh-in-motion (LSWIM) system for more precise weight measurement; from there they will be directed either into a parking area for ticketing, unloading, or load redistribution or back to the main highway lanes. The signing and signalization needed to facilitate these maneuvers are discussed below.

Exit and Entrance Ramps

Exit and entrance ramps connecting the weigh station to the highway main lanes should be of conventional design. Since heavy commercial vehicles will be expected to exit at highway speeds, the taper on the ramp should be quite gentle. A taper value of about 17 or 18 to 1 is recommended.

Deceleration and Acceleration Distances

The facility must provide sufficient space for two crucial deceleration maneuvers. The distance from the gore of the exit ramp to the HSWIM system should be not less than approximately 190 m (625 ft), which is generally an adequate distance for vehicles to decelerate from 100 to 60 km/h (60-35 miles/h) with minimal braking. Sufficient distance must also be provided for deceleration from 60 km/h at the HSWIM with minimal braking to a speed of approximately 16 km/h (10 miles/h) at the LSWIM. A minimum of 75 m (250 ft) is recommended for the distance between the HSWIM and LSWIM systems. Minimum distance requirements are computed on the basis of deceleration rates of 1.2 m/s^2 (4 ft/s^2), which can generally be obtained with minimal braking.

A minimum acceleration distance from the location of the LSWIM scale to the gore of the entrance ramp along the highway should be approximately 400 m (1300 ft). This distance is computed by assuming initial and terminal speeds of 15 and 80 km/h (10 and 50 miles/h) and a 0.6-m/s^2 (2-ft/s^2) acceleration rate.

Ingress and Egress to Parking and Reloading Area

The circular ramps leading into and out of the parking area shown in Figure 1 should be provided with a sufficient curve radius to accommodate maximum vehicle speeds of 40 km/h (25 miles/h). The minimum radius of the curves in Figure 1 is approximately 35 m (115 ft); this will accommodate 40-km/h speeds with no superelevation.

The physical size of the parking area is largely a function of the quantity of expected truck traffic. It also depends, however, on the nature of the functions to be performed. If overweight trucks are expected to unload or redistribute loads before being allowed to proceed, delay times will be greater and more space will be required.

Alternative Configurations

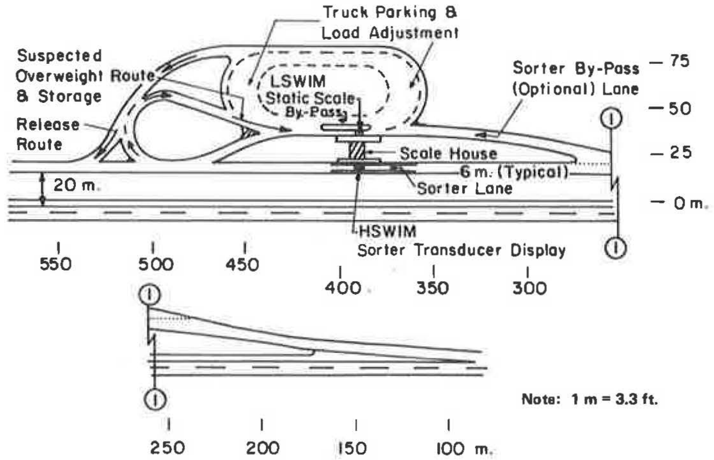
Many alternative configurations for WIM enforcement stations can, and no doubt will, be developed. One problem associated with the scheme presented in Figure 1 is the 200-m (650-ft) distance between the system operator in the scale house and the HSWIM system sensors. The operator cannot easily maintain visual surveillance of the HSWIM sensors. Under some conditions, this can be a serious problem.

Figure 2 shows an alternative configuration scheme that places the HSWIM and LSWIM systems (or a static scale) within easy view of the operator. This scheme also, in effect, forces vehicles to decelerate before they pass over the LSWIM system. Although it does offer these advantages, this configuration might represent a greater capital investment and would likely require somewhat more lost user time.

TRAFFIC CONTROL

At conventional weigh stations, each axle, or axle

Figure 2. Alternative configuration for vehicle-weight-enforcement station.



group, of every truck must be weighed while the truck is stopped on a static scale in order to determine whether or not the axle weight and the gross vehicle weight are within the applicable legal limits. Traffic control within this type of station involves, first, telling the truck driver when and where to stop for weighing and dimensioning and then advising the driver whether to proceed back to the through roadway or to a parking area for violators.

The use of in-motion weighing and dimensioning techniques at enforcement stations requires considerably different traffic controls within the station. As explained earlier in this paper, the accuracy with which static axle weights can be estimated from samples of the varying wheel force of a moving truck is limited by factors that influence the dynamic behavior of the truck, such as speed, road roughness, and the condition of the truck tires. These limitations on accuracy can, however, be recognized, and the technique can provide a safe, efficient, economical means of detecting weight-limit violators without harassing the legally loaded truck operators.

At a WIM enforcement station, appropriate traffic controls must be provided so that weighing can be accomplished in two stages. First, an HSWIM system determines within, say, ±10 percent the weight of each axle and axle group on the truck as it travels at about 60 km/h (35 miles/h). If, after this rough screening, the truck is suspected of violation, a more accurate weight determination must be made. The suspected violator will be directed by a traffic-control signal into a lane where further weight examination can be accomplished. If the truck is obviously legally loaded, the traffic-control signal will guide the truck into a bypass lane where it can accelerate and return to the through roadway without stopping.

The second stage of weighing, which involves only those trucks that approach or exceed the legal limits, must be accomplished within appropriate legal tolerances. Either conventional static weighing or LSWIM techniques can be used at this stage. Since axle weighing and dimensioning with conventional methods normally takes about 1-4 min, depending on the equipment used, the operator's proficiency, the skill and cooperation of the driver, the weather, and other factors, storage space must be provided for a queue of trucks waiting to be weighed. Traffic-control signs or signals are required to advise the drivers when and where to stop. The location of the end of the queue must be considered in designing the traffic-control system as well as the geometric configuration of the static weighing lane.

Even though it is not legally recognized at this time, the LSWIM technique offers significant advantages over static weighing for second-stage weighing, particularly when it is combined with HSWIM sorting, as described above. LSWIM measurements are made with the truck moving at less than about 25 km/h (15 miles/h). At these slow speeds, the dynamic behavior of the vehicle is such that estimates of static axle weight can probably be made reliably within 2 percent when proper equipment and techniques are used. Because the truck brakes are not in use during LSWIM sampling and the load transfer through suspension-system friction is perhaps reduced by the slow forward motion of the truck in comparison with the stopped condition, two of the major sources of static-weighing error are eliminated. Experience has shown that successive static weighings of the same truck axle frequently vary by more than 20 percent even though the scales are certified to 0.2 percent maintenance tolerance. It is probable that an LSWIM system certified to, say, 1 percent tolerance would consistently produce axle-weight estimates that are at least as accurate as weights obtained by a single static axle-load scale used in the usual way. Comprehensive testing is needed to determine the actual accuracy within which a high-quality LSWIM system can operate under field conditions. Legal acceptance of in-motion weighing for enforcement purposes can then be gained for a proven system.

Another advantage of LSWIM relates to traffic-handling capacity. With trucks passing over the sensors at 16 km/h (10 miles/h) on 6-s average headways, 10 trucks/min can be processed. A single axle-load scale can process only about 20 trucks/h and there are long delays for the trucks waiting in the queue. These are, of course, maximum rates, but stochastic arrival times at the scales can produce high demand for short periods of time. LSWIM can handle the peak demands much more effectively than a static axle-load scale.

Traffic flow through an LSWIM system is smooth and uninterrupted. Signs advise drivers of the maximum speed [e.g., 25 km/h (15 miles/h)], and a post-mounted traffic-control signal beyond the LSWIM sensors directs them either back to the through roadway if the truck is legally loaded or into a parking area if it is in violation. A legally loaded truck that is determined to be suspect by HSWIM loses only a few seconds of total time while it is being checked by LSWIM. An illegally loaded truck is detected quickly by LSWIM and directed to

Table 2. Types and locations of traffic-control devices for WIM enforcement station.

Objective	Traffic-Control Device	Location
Direct all trucks from roadway into weigh station via exit ramp	Advance sign (D8-1)[a]: WEIGH STATION 1 MILE	1600 m before exit gore
	Weigh-station sign: ALL TRUCKS COMMERCIAL VEHICLES NEXT RIGHT	1200 m before exit gore
	Exit direction sign: WEIGH STATION NEXT RIGHT (OPEN/CLOSED)	450 m before exit gore
	Gore sign (D8-3)[a]: WEIGH STATION	In exit gore
Effect speed reduction to steady speed of <60 km/h when truck crosses HSWIM sensors, located approximately 190 m beyond exit gore	Speed-limit sign (R2-1)[a], 92x123 cm: SPEED LIMIT 35	Right-hand side of ramp, 20 m beyond exit-gore sign
Advise drivers to maintain 35-m clear spacing between trucks	Special sign, 92x123 cm, white on black: KEEP 100 FEET SPACING	Right-hand side of ramp, 60 m beyond exit-gore sign
Center truck laterally in lane so it passes over HSWIM sensors	Pavement edge lines: yellow on left, white on right, 15 cm wide	Beginning at lane edge 50 m in advance of HSWIM sensors and tapering inward to edge of sensors
After HSWIM sorting, guide legal-weight trucks into bypass lane, where they can accelerate and return to roadway	Traffic signals: upward-pointing green arrows rotated 45° to left	Overhead signal 75 m beyond HSWIM sensors and post-mounted signal in gore 120 m beyond HSWIM sensors
	Special sign, 92x123 cm, white on black: WEIGHT O. K. RESUME SPEED	Left-hand side of bypass lane, 50 m beyond gore
After HSWIM sorting, direct suspected weight violators into LSWIM lane (alternatively, static scales can be located in this lane)	Traffic signals: upward-pointing green arrows rotated 45° to right	Overhead signal 75 m beyond HSWIM sensors and post-mounted signal in gore 120 m beyond HSWIM sensors
Effect speed reduction to steady speed of <25 km/h when suspected weight-limit violator crosses LSWIM sensors, located approximately 130 m beyond gore to bypass lane[b]	Speed-limit sign (R2-1)[a], 61.5x77 cm: SPEED LIMIT 15	Right-hand side of lane, 70 m beyond gore at bypass-LSWIM lane
Center truck laterally in lane so it passes over LSWIM sensors[b]	Pavement edge lines: yellow on left, white on right, 15 cm wide	Beginning at lane edge 50 m in advance of HSWIM sensors and tapering inward to edge of sensors
Advise drivers not to stop on LSWIM sensors[b]	Special sign, 61.5x77 cm: DO NOT STOP ON SCALES	Right-hand side of lane, 10 m in advance of LSWIM sensors
After LSWIM weighing, guide legal-weight trucks back to roadway	Traffic signal: upward-pointing green arrow rotated 45° to left	Post-mounted signal in gore beyond LSWIM sensors
	Special sign, 61.5x77 cm: WEIGHT O.K. RESUME SPEED	Left-hand side of return lane, 100 m beyond gore
After LSWIM weighing, direct weight-limit violators into parking area for load adjustment, unloading, or ticketing	Traffic signal: upward-pointing green arrow rotated 45° to right	Post-mounted signal in gore beyond LSWIM sensors

Note: 1 km = 0.62 mile, 1 cm = 0.39 in, and 1 m = 3.3 ft.
[a]Designations from Manual on Uniform Traffic Control Devices (3).
[b]Objective does not apply if static scales are used. Appropriate signs, signals, and voice commands will be used to position each truck on the scales.

an area where appropriate enforcement measures can be taken.

PRINCIPLES OF TRAFFIC CONTROL IN USE OF WIM

The following discussion is predominantly related to the station configuration shown in Figure 1, which uses both HSWIM and LSWIM systems, but the principles of traffic control that are presented are applicable to the configurations shown in both Figures 1 and 2. Traffic control associated with the HSWIM system is unique and thus of major concern.

In-motion weighing is a new concept for truck drivers. Through prior knowledge and experience, they expect to stop at a weigh station. The traffic-control system at a WIM enforcement station must, therefore, overcome this preconceived notion and cause the driver to travel confidently through the station at appropriate speeds with safe clearances between trucks. The desired objectives for the traffic-control system are given in Table 2 along with suggested traffic-control devices and locations for the devices. The devices conform to provisions in the Manual on Uniform Traffic Control Devices (3) as much as is practicable.

The geometry shown in Figure 1 provides appropriate distances between decision points for the driver and suitable locations for the required devices described in Table 2. It will be instructive to track the progress of a vehicle through the WIM enforcement station and analyze the suggested traffic-control system.

Conventional weigh-station signing directs all trucks onto a standard, tapered exit ramp where a SPEED LIMIT 35 regulatory sign informs the driver of the maximum permitted speed. Sufficient distance beyond the exit gore is provided for the truck to decelerate comfortably and attain a steady speed before reaching the HSWIM sensors ahead. About 2 s later, a special KEEP 100 FEET SPACING sign advises the driver to keep a safe following distance. The limited speed allows the HSWIM system to make better estimates of static axle weights, and the suggested spacing allows the driver adequate signal-viewing time before reaching the bypass-LSWIM gore ahead. The HSWIM system measures speed and acceleration as well as axle weights. If a truck exceeds the posted speed limit or accelerates or decelerates excessively, the weight estimates may not be as good as desired; therefore, the control system will automatically signal the truck into the LSWIM lane for further examination. The HSWIM system is capable of properly making all measurements of each truck unless the clear spacing between trucks is less than about 10 m (33 ft); however, an unsafe, clear spacing of 1 s at 60 km/h [17 m (56 ft)] will allow the driver only 2.8 s to view the traffic-control signals described below (see Figure 3). This is perhaps adequate time in these extreme circumstances. At the normally recognized safe spacing between vehicles of 2 s at 60 km/h [33 m (100 ft)], the driver of a very long [20-m (65-ft)] truck will have 3.9 s to view the signals and steer to one side or the other of the bypass-LSWIM gore. Shorter vehicles and those going slower than 60 km/h will have more signal-viewing time (Figure 3).

The suggested traffic-signal arrangement that is controlled by the HSWIM system is shown in Figure 4. A three-section signal face, S-1, is mast-arm mounted overhead 75 m (250 ft) beyond the HSWIM

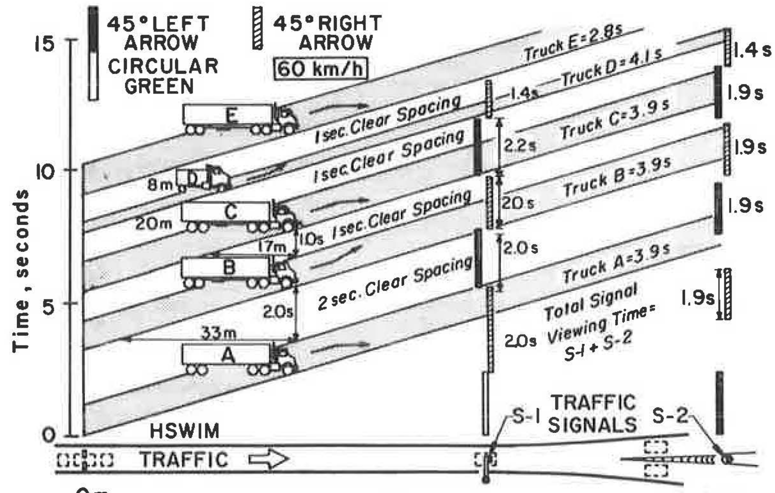
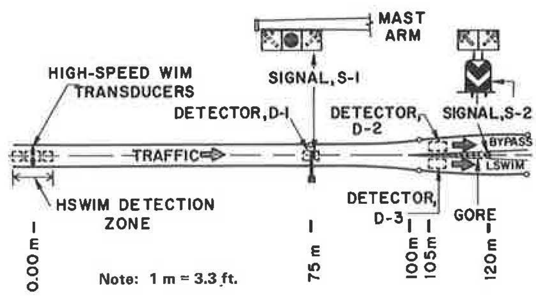


Figure 3. Time-space diagram for signals controlled by HSWIM system.

Figure 4. Arrangement of traffic signals controlled by HSWIM system.



sensors. One signal indication is illuminated at all times to attract the attention of the approaching driver to the signal. Circular green is presented at all times when HSWIM is not calling for an arrow indication for a specific truck; this locates the signal in the space ahead and encourages the approaching driver to keep moving. The left-pointing green arrow at S-2, which is a post-mounted (breakaway), two-section signal in the bypass-LSWIM gore 120 m (400 ft) beyond the HSWIM detectors, will be illuminated simultaneously with the circular green at S-1.

Within 1 s after a truck clears the HSWIM detection zone, the system determines whether any limiting speed, acceleration, single-axle weight, axle-group weight, gross vehicle weight, wheelbase, or position of tires on the transducers has been violated and illuminates the appropriate green arrow at S-1. This indication continues until detector D-1 underneath the signal is actuated by the approaching truck. The actuation frees S-1 and transfers the same arrow indication to S-2 in the gore directly ahead for continued viewing by the driver. When the truck actuates either detector D-2 or D-3, the indication at S-2 is terminated. Optically programmed signals are recommended for S-2 so that, after the driver has passed D-2 or D-3, any subsequent arrow indication will not be visible to cause confusion. The HSWIM system determines from detector D-2 or D-3 actuation whether the driver obeyed the arrow signal; if not, an alarm is given in the scale house to alert enforcement personnel. Signals S-1 and S-2 thus safely guide the driver into either the bypass lane or the LSWIM lane as appropriate. Conventional arrow signal indications, with which all drivers are familiar, are used. Provision of adequate signal-viewing time and driver reaction time results in a minimum chance of confusion. The driver simply obeys the traffic-signal indication that appears directly ahead.

The driver of a truck that is not suspected of weight-limit violation is directed into the left-hand or bypass lane and is free to accelerate and return to the through roadway. A special WEIGHT O.K. RESUME SPEED sign located beyond the gore communicates this message to the driver.

The suspected violator in the LSWIM lane is advised of a reduced speed limit by a SPEED LIMIT 15 sign located some 70 m (230 ft) beyond the gore. A sign DO NOT STOP ON SCALES informs the driver that it is not necessary to stop for weighing at this location.

After the LSWIM system has determined whether or not the suspect is, in fact, in violation of the legal weight limits, a gore-mounted signal, S-3, directs the truck to either return to the through roadway or go into a parking area for enforcement action. A special WEIGHT O.K. RESUME SPEED sign is provided for the legally loaded trucks that are released by the LSWIM system. At the lower speeds, one signal face at the gore provides adequate time for driver response.

SUMMARY

In recent years, in-motion truck weighing techniques have been developed to the stage that estimates of static axle weights can be made reliably to within approximately 10 percent for trucks traveling at speeds as high as 60 km/h (37 miles/h) or even higher, and much more accurately at speeds below, say, 20 km/h (12 miles/h). These techniques can now be applied for purposes of weight-limit enforcement in a two-stage weighing process to sort obviously legally loaded vehicles from suspected violators with high-speed weighing and then check the suspects for actual violation by either accurate low-speed weighing or static weighing. Legally loaded vehicles need not be subjected to the safety hazards or costs associated with stopping and waiting for static weighing, and the enforcement agency can practically and economically examine every truck that passes on the highway for possible weight and length violations.

Various geometric configurations for WIM enforcement stations are possible; two arrangements are given in this paper. Since drivers expect to stop at a weigh station, new traffic-control schemes are needed at all WIM enforcement stations to guide each driver through the station at appropriate speeds and appropriate spacings from the vehicle ahead. A combination of signs, pavement markings, and traffic-control signals is recommended for this purpose.

Overall safety, efficiency, convenience, and economy in truck-weight-enforcement operations can be achieved with properly designed WIM equipment, weigh-station layouts, and traffic-control systems. The weigh-station features suggested in this paper are chosen to foster these objectives.

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