HUNTON & WILLIAMS
1900 K STREET, N.W.
WASHINGTON, D.C. 20006-1109
TELEPHONE (202) 955-1500
FACSIMILE (202) 778-2201

ATLANTA, GEORGIA
BANGKOK, THAILAND
BRUSSELS, BELGIUM
CHARLOTTE, NORTH CAROLINA
HONG KONG
KNOXVILLE, TENNESSEE
LONDON, ENGLAND

MCLEAN, VIRGINIA
MIAMI, FLORIDA
NEW YORK, NEW YORK
NORFOLK, VIRGINIA
RALEIGH, NORTH CAROLINA
RICHMOND, VIRGINIA
WARSAW, POLAND

RICHARD L. AGUGLIA
E-MAIL: RAGUGLIA@HUNTON.COM

FILE NO.: 57136.000002
DIRECT DIAL: (202) 955-1634

May 3, 2000

'00 MAY -3 AM 11:56
OFFICE OF ZONING
DISTRICT OF COLUMBIA

Ms. Sheila Cross Reid, Chairperson
c/o Sheri Pruitt
Board of Zoning Adjustment
441 - 4th Street, N.W.
Room 210
Washington, DC 20001

Re: BZA Application No. 16559
(Field School - Special Exception Request
under Sec. 206 of the Zoning Regulations)

Dear Ms. Reid and Board Members:

Enclosed is a traffic safety and highway design analysis prepared by Fred R. Hanscom, P.E., Transportation Research Corporation, to be filed in this case. Mr. Hanscom, who will testify as an expert witness at the May 10, 2000 hearing in this case on behalf of Neighbors Against Foxhall Gridlock, has found that the Gorove/Slade revised southern entrance traffic proposal for the development of the Field School on Foxhall Road violates the AASHTO guide and the requirements of the Manual on Uniform Traffic Control Devices which will result in safety problems for Foxhall Road motorists.

By way of background, the prior hearing on the Field School's application was bifurcated to exclude testimony and exhibits on traffic impact (until May 10, 2000) because of the late filing of a revised traffic plan by the applicant. The applicant was given until April 18, 2000 to submit final traffic plans to the Board and parties in opposition. Parties in opposition were given until May 3 to respond, which prompts the instant filing, to the applicant's final traffic plan.

Sincerely,

Richard L. Aguglia

Richard L. Aguglia

Enclosure

BZA
Case No. 16559
Exhibit No. 416

Board of Zoning Adjustment
District of Columbia
CASE NO.16559
EXHIBIT NO.416

By hand delivery

cc: Phil Feola, Esq.
Counsel for Applicant

Ellen McCarthy, Office of Planning

Ken Laden, DPW

By overnight mail

Anne Heuer, ANC 3D, SMD
Eleanor Lewis, ANC 3D

bcc: Ken Woodcock
Joe Mehra
Ken Doggett
Jeff Bolotin
Lou Nevins

(540)364-6296
fax: (540)364-6297
e-mail: trc@trc-net.com

TRC TRANSPORTATION RESEARCH CORPORATION

11671 Audubon Trail
Markham, VA 22643

May 1, 2000

'00 MAY -3 A11:58
DISTRICT OF COLUMBIA
OFFICE OF ZONING

Richard Aguglia, Esq.
Hunton and Williams
Suite 1200
1900 K Street, N.W.
Washington, DC 2006-1109

RE: Field School Application No. 16559 Before the District of Columbia Board of Zoning Appeals

Dear Mr. Aguglia:

I have reviewed the Gorove/Slade proposal for the development of the Field School on Foxhall Road at the Cafritz Estate north of W Street in the District of Columbia. My consideration of this matter has addressed traffic control and highway design aspects of the Gorove/Slade proposal and their implications with regard to safety.

My qualifications to address this matter include 30 years of highway safety research experience, previous employment as a Highway Design Engineer with Arlington County, and current membership on the National Committee on Uniform Traffic Control Devices. This committee writes the *Manual on Uniform Traffic Control Devices*, which is the national standard regulating signs, signals, and pavement marking for all U.S. public streets and highways. I am the Human Factors Representative to the committee, and I am a member of its Executive Board. I have been qualified as an expert witness in the areas of traffic safety and highway design in 18 states and the U.S. Virgin Islands.

My qualifications to determine appropriate vehicle speeds at a given location derive, in part, from my directing a major Federal Highway Administration study, *Improved Techniques for Collection of Speed Data,* (Contract DTFH61-82-C-00064, which was completed in 1984).

Having reviewed the Gorove/Slade proposal, I noted a number of irregularities that violate provisions of both the *Manual of Uniform Traffic Devices* and *A Policy on Geometric Design of Highways and Streets*[1] (referenced herein as the "AASHTO guide"). The nature of these violations give rise to a safety problem stemming from the fact that southbound Foxhall Road drivers would not be adequately advised of the left-turn lane into the Field School. This problem, in combination with the approach sight-distance restriction, produces an accident-prone situation.

I have developed specific findings in this matter as follows.

[1] This publication of the American Association of State Highway and Transportation Officials (AASHTO) comprises the nationally accepted guideline for recommended U.S. highway design practices.

1. The 40-mph design speed applied in the Gorove/Slade analysis accurately reflects southbound Foxhall Road traffic conditions.

As part of my investigation, I conducted speed observations of randomly selected free-flow vehicles during both the a.m. and p.m. peak periods. My observed a.m. period sample size was adequate to support determination of the mean speed to +/- 1.0 m.p.h. with a 95-percent level of statistical confidence. The observed sample mean speed was 36.5 m.p.h., and the 85th percentile speed was 40 m.p.h. The 85th percentile is the appropriate speed to be applied for design purposes. Therefore, the result of my speed study supports Gorove/Slade's application of 40 m.p.h. for use in the development highway geometric or traffic control features.

2. Gorove/Slade improperly applied AASHTO geometric principles in designing the left-turn "stacking" lane.

Gorove/Slade's "Sight Distance Plan and Profile Plan for Foxhall Road" cited a 40-m.p.h. design speed and a sight distance of 300 feet. However, 300 feet is an unsafe sight distance for a 40-m.p.h. design speed; and it violates provisions of the AASHTO guide. The following paragraphs will explain this inconsistency with regard to the proposed "stacking lane".

Gorove/Slade provided pages 828 though 830 of the AASHTO guide as its basis for the development of a 40-m.p.h. "Auxiliary Lane" (see Exhibit 1). However, the cited AASHTO procedure specifically applied to design condition consisting of two percent (or flatter) grades. Nevertheless, the profile plan submitted by Goroove/Slade indicates a downgrade exceeding 7.5 percent, between the proposed north and south entrances. This downgrade increases a motorist's stopping distance, thus creating a more hazardous situation than acknowledged by Gorove/Slade.

In view of the crucial safety issue surrounding a 40-m.p.h. design speed in the context of a 300-foot sight distance, the appropriate design consideration for highway improvements is the stopping sight distance. The importance of stopping sight distance is summarized in the AASTHO guide, as follows.

"Sight distance is the length of roadway ahead visible to the driver... (and) must be available at every point along the highway (for a) vehicle to stop in this distance... Stopping sight distance is the sum of two distances: (1) the distance traversed by the vehicle from the instant the driver sights an object necessitating a stop to the instant the brakes are applied, and (2) the distance required to stop the vehicle from the instant the brake application begins."

It is important to note that the above definition does not consider situations in which an object may be difficult to perceive or understand, e.g., a partially hidden obstruction. This concept is known as "decision sight distance", which is essential in de-

termining traffic control requirements such as advance signing or visible pavement markings.

The AASHTO guide provides stopping sight distance values for associated speeds in Table III-1 (see Exhibit 2). As seen from this exhibit, the 40-mph stopping sight distance is 325 feet, i.e., longer than the 300-foot value indicated by Gorove/Slade. It should be noted that wet pavement conditions are considered in the determination of stopping sight distance for safety reasons. However, the 325 distance applies to a level pavement rather than the actual 7.5 percent downgrade, as acknowledged by Gorove/Slade. The AASHTO guide provides a formula (see Exhibit 3) for adjusting the stopping sight distance in downgrade situations. When the applicable adjustment is applied to Foxhall Road (approaching the south entrance), the actual stopping sight distance was determined to be 364 feet. With regard to Auxiliary Lane development (as noted on page 828 of the AASHTO guide, see Exhibit 1), 364 feet is the required "deceleration length".

The AASHTO auxiliary lane design procedure further notes that deceleration lengths do not include taper lengths, i.e., the hash-marked area in advance of the vehicle storage bay. Page 830 of the AASHTO guide (on Exhibit 1) procedure notes a formula for developing taper lengths. If applied in this case, the taper would require an additional 267 feet of the auxiliary lane. Other accepted techniques for developing taper lengths would indicate that the taper could be shorter than 267 feet; however, considering the restricted southbound Foxhall Road sight distance, the recommended 267-foot distance is appropriate to advise approaching motorists of the auxiliary lane presence. As is also documented in the AASTHO guide (on Exhibit 1), a vehicle storage bay length (indicated by Gorove/Slade to be approximately 250 feet) is also required in addition to the deceleration and taper distances.

Utilizing the above auxiliary lane design requirements contained in the AASHTO guide, the recommended auxiliary lane length is, (1) a 364-foot deceleration lane, (2) a 267-foot taper, and (3) a vehicle storage lane (designated by Gorove/Slade as 250 feet). Thus it is apparent that the total auxiliary lane length, in accordance with the AASHTO guide designated by Gorove/Slade is 881 feet. Considering that the proposed left turn is 200 feet north of the southern property line, the taper would need to begin at a distance of 361 feet[2] north of the Field School property.

Given the restricted sight distance (i.e., vertical crest and curve) approach to the northern property boundary, the 361-foot advance taper is also required to meet "decision sight distance" requirements.

---

[2] The distance of 361 feet north of the property line is derived as follows. As indicated, the total length of the turn lane is 881 feet. As the south entrance is 200 feet north of the southern property line and the frontage is 720 feet, the turn lane would extend to {200 + 881- 720} or 361 feet north of the northern property boundary.

3. **A left-turn lane that accommodates the anticipated turning traffic volume and conforms to AASHTO highway design guidelines can not be constructed, as proposed, along the Field School frontage.**

As noted above, the length of a turning lane that conforms to AASHTO highway design criteria would be substantially longer than the Cafritz Estate frontage. The entire length of the turn lane would involve widening the affected portion of Foxhall Road. Therefore, the left turn lane can not be constructed by utilization of an easement onto the Chafitz estate property.

4. **The proposed auxiliary lane fails to meet requirements of the *Manual on Uniform Traffic Control Devices (MUTCD).***

The auxiliary lane's taper (i.e., yellow painted hashed pavement marking) and vehicle storage bay comprises a traffic control device. Also known as a "re-directional transition", the taper's function is to advise approaching motorists of the presence of a turn lane. Those drivers intending to use the turn bay need to be to advised in time to make the necessary transition into the turn bay. Therefore, it is necessary that the taper be visible at a sufficient advance distance in order to provide notice of the prerequisite maneuver into the storage bay.

The MUTCD is the national standard for traffic control devices, and the DC government is obliged to comply. The MUTCD sets forth a number of basic requirements for traffic control devices, including that devices "command attention" and "give adequate time for proper response". Specifically, Section 1A-2 (under *Placement*) requires that its location "is such that a driver traveling at normal speed has adequate time to make the proper response" (see Exhibit 4).

The advance distance for making a proper response is determined via application of "decision sight distance" considerations similar to those contained in the 1990 AASHTO highway design guide. That is, an approaching driver requires sufficient advance sight distance to detect an object, recognize it, and decide on the appropriate preparatory maneuver prior to arriving at the object. In this case, it is necessary for a driver to recognize and understand the transitional-taper pavement marking prior to initiating a maneuver into the storage bay. This condition is necessary for meeting the MUTCD's "adequate time for proper response" requirement.

In view of observed Foxhall Road speeds, in combination with the limited approach sight distance, the proposed Gorove/Slade auxiliary lane fails to meet the applicable decision sight requirement. Therefore, it is my opinion that the proposed auxiliary lane fails to meet provisions of the MUTCD. I have photographed examples of appropriately installed turn-lane tapers at restricted sight-distances locations and plan to present these at the May 10 hearing.

5. The sight distance for left turning movements from the north entrance is not adequate.

Referring to the documented 1990 AASHTO guide procedure for determining left-turn sight distance requirements, and applying a 40-m.p.h design speed, the necessary left-turn sight distance to the right is not available. The Kreeger Museum fence blocks the sight line to potentially conflicting southbound Foxhall Road vehicles approaching from the right.

6. As indicated on the auxiliary lane plan, the sight distance for right turning movements from the south entrance is not adequate.

The 1990 AASHTO sight-distance criteria require unobstructed views of approaching traffic. The plan submitted by Gorove/Slade shows a tree in the vicinity of the south driveway that limits the sight distance of approaching northbound vehicles to a distance of approximately 220 feet, which is inadequate for northbound Foxhall Road. I plan to submit a photograph at the May 10 hearing that illustrates the visual blockage resulting from the tree.

7. Implementation of the proposed Gorove/Slade plan would result in a safety problem.

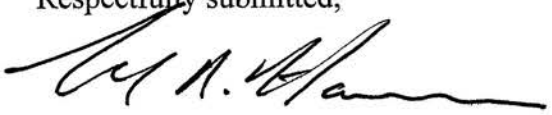
As noted above, given the 40-m.p.h. design speed on a 7.5 percent downgrade, the wet-pavement stopping distance on southbound Foxhall Road is 364 feet. This stopping distance far exceeds the available sight distance as southbound motorists approach the proposed left turn lane. The obvious safety consequence this condition is the inherent danger of a "blind driver" rear-end accident.

As southbound drivers approach the Field School, a vertical crest restricts visibility of the proposed turn lane. Thus, it is foreseeable that drivers would "overshoot" the turn lane, i.e., not being able to enter the storage bay due to previously queued vehicles. In this event, there is a distinct likelihood of stopped traffic in the southbound lane, creating a severe rear-end accident threat from additional traffic coming over the crest.

CONCLUSION

The Gorove/Slade development plan for the Field School at the Cafritz Estate violates a number of critical provisions of the national highway design guideline and traffic control device standard. These violations resulted in a foreseeable safety problem for Foxhall Road motorists.

Respectfully submitted,



Fred R. Hanscom, P.E.

AUXILIARY LANES

General Design Considerations

From the foregoing discussions it is appropriate to deal with the design elements of auxiliary lanes as they relate to median openings and left-turning movements. In general, auxiliary lanes are used preceding the openings as described in this section and are also used at at-grade intersections preceding and following right turning movements to accommodate speed changes, weaving and maneuvering of traffic. Auxiliary lanes may also be added to increase capacity through an intersection.

Auxiliary lanes should be at least 10 ft wide and desirably should equal that of the through lane. Where curbing is to be used adjacent to the auxiliary lane, an appropriate curb offset should be provided. The length of the auxiliary lanes for turning vehicles consists of three components: (1) deceleration length (2) storage length and (3) entering taper.

Desirably, the total length of the auxiliary lane should be the sum of the length for these three components. Common practice, however, is to accept a moderate amount of deceleration within the through lanes and to consider the taper as a part of the deceleration length. Where intersections occur as frequently as four per mile, it is customary to forego most of the deceleration length and to provide only the storage length plus taper. Each component of the auxiliary length is discussed in the following section.

Deceleration Length

Provision for deceleration clear of the through-traffic lanes is a desirable objective on arterial roads and streets and should be incorporated into design whenever feasible. The total length required is that needed for a safe and comfortable stop from the design speed of the highway. Minimum deceleration lengths for auxiliary lanes on grades of 2 percent or less, with an accompanying stop condition, for design speeds of 30, 40 and 50 mph are 235, 315 and 435 ft respectively.

These lengths exclude the length of taper which should be approximately 8 to 15 ft longitudinally to 1 ft transversely. Long tapers indicate the path drivers are to follow and reduce the unused portion of the pavement. However, long tapers tend to entice some through drivers into the deceleration lane. On the other hand, shorter tapers produce better "targets" for approaching drivers and give positive visibility of the added auxiliary lane.

On many urban facilities it will not be feasible to provide full length for deceleration. In such cases at least a part of the deceleration must be accomplished before entering the auxiliary lane. However, the lengths given should be accepted as a desirable goal and should be provided where practical and feasible. Deceleration lengths shown are applicable to both left and right-turning lanes, but speed is usually lower in the right lane than in the left lane.

Storage Length

The auxiliary lane should be sufficiently long to store the number of vehicles likely to accumulate during a critical period. The storage length should be sufficient to avoid the possibility of left-turning vehicles stopping in the through lanes. The storage length should be sufficiently long so that the entrance to the auxiliary lane is not blocked by vehicles standing in the through lanes waiting for a signal change or for a gap in the opposing traffic flow.

At unsignalized intersections the storage length, exclusive of taper, may be based on the number of turning vehicles likely to arrive in an average 2-min period within the peak hour. As a minimum requirement, space for at least two passenger cars should be provided; with over 10 percent truck traffic, provisions should be made for at least one car and one truck. The 2-min waiting time may need to be changed to some other interval that depends largely on the opportunities for completing the left-turn maneuver. These intervals, in turn, depend on the volume of opposing traffic. Where the volume of turning traffic is high, a traffic signal will usually be required.

At signalized intersections the required storage length depends on the signal cycle length, the signal phasing arrangement, and the rate of arrivals and departures of left-turning vehicles. The storage length is a function of the probability of occurrence of events and should usually be based on one and one-half to two times the average number of vehicles that would store per cycle, which is predicated on the design volume. This length will be sufficient to serve heavy surges that occur from time to time. As in the case of unsignalized intersections, provision should be made for storing at least two vehicles.

Traffic signal design fundamentals are discussed further in MUTCD (**5**).

Where turning lanes are designed for two-lane operation, the storage length is reduced to approximately one-half of that required for single-lane operation. Reference should be made to the *Highway Capacity Manual* (**2**).

Taper

On high-speed highways the taper of an auxiliary lane should generally conform to that discussed under "Ramp Terminals" in the section "Speed-Change Lanes" in Chapter X. However, on most urban streets approaching at-grade intersections, shorter tapers are satisfactory because of lower operating speeds.

Some States permit the tapered section of deceleration auxiliary lanes to be constructed in a "squared-off" section at full paving width and depth. This construction requires a painted delineation of the taper and is only applicable to noncurbed sections. The design requires transition of the outer or median shoulders around the squared-off beginning of the deceleration lane.

The squared-off design principle can be applied to median deceleration lanes, and it can also be used at the beginning of deceleration right-turn exit terminals when there is a single exit lane. When two or more exit lanes are used, the tapered designs discussed in the section "Speed-Change lanes" in Chapter X is recommended.

Additional guidance for lengths of tapers may be found in the "Manual of Uniform Traffic Control Devices" (**5**) which recommends the following for design speeds equal to or greater than 45 mph: length of taper (L) equals the design speed (S) multiplied by the offset (W), $L = SXW$. For design speeds equal to or less than 40 mph; the length of taper (L) equals the offset (W) multiplied by the design speed (S) squared, then divided by 60, or $L = WS^2/60$.

Some State highway agencies believe that the abrupt squared-off beginning of deceleration exits offers improved driver commitment to the exit maneuver and also contributes to driver security and safety because of the elimination of the unused portion of long tapers. For example, a 15:1 taper ratio is recommended for design speeds up to 50 mph. If the auxiliary lane was 12 ft wide, the taper length would be 180 ft. This approach section could be 12 ft wide and constructed for its full length. The painted delineation taper could be 12 ft wide and constructed for its full length. The painted delineation taper could be established on a 4:1 ratio that would produce a stripe approximately 50 ft long. This design principle could be applied to all deceleration design speeds and should operate with relatively quick exit maneuvers to the full-width lane under low design speeds and still provide for the longer exit maneuvers at the higher design speeds.

The longitudinal location along the highway, where a vehicle will move from the through lane to a full-width deceleration lane, will vary depending on many factors. These factors include the type of vehicle, the driving characteristics of the vehicle operator, the speed of the vehicle, weather conditions, and lighting conditions.

Design Speed (mph)	Assumed Speed for Condition (mph)	Brake Reaction Time (sec)	Brake Reaction Distance (ft)	Coefficient of Friction f	Braking Distance on Level (ft)	Stopping Sight Distance Computed (ft)	Stopping Sight Distance Rounded for Design (ft)
20	20-20	2.5	73.3-73.3	0.40	33.3-33.3	106.7-106.7	125-125
25	24-25	2.5	88.0-91.7	0.38	50.5-54.8	138.5-146.5	150-150
30	28-30	2.5	102-7-110.0	0.35	74.7-85.7	177.3-195.7	200-200
35	32-35	2.5	117.3-128.3	0.34	100.4-120.1	217.7-248.4	225-250
40	36-40	2.5	132.0-146.7	0.32	135.0-166.7	267.0-313.3	275-325
45	40-45	2.5	146.7-165.0	0.31	172.0-217.7	318.7-382.7	325-400
50	44-50	2.5	161.3-183.3	0.30	215.1-277.8	376.4-461.1	400-475
55	48-55	2.5	176.0-201.7	0.30	256.0-336.1	432.0-537.8	450-550
60	52-60	2.5	190.7-220.0	0.29	310.8-413.8	501.5-633.8	525-650
65	55-65	2.5	201.7-238.3	0.29	347.7-485.6	549.4-724.0	550-725
70	58-70	2.5	212.7-256.7	0.28	400.5-583.3	613.1-840.0	625-850

Table III-1. Stopping sight distance (wet pavements).

Exhibit 2

should be considered when tests yield coefficients of friction significantly below those in Table III-1.

Table III-1 includes data for the higher design speeds for wet conditions where no actual test data are available. Values for design speeds above 60 mph are extrapolated from the curves for lower speeds in Figure III-1A.

Effect of Grade on Stopping

When a highway is on a grade, the standard formula for braking distance is the following:

$$d = \frac{V^2}{30(f \pm G)}$$

in which G is the percent of grade divided by 100, and the other terms are as previously stated. The safe stopping distances on upgrades are shorter; those on downgrades are longer. The extent of grade corrections is indicated in Table III-2. These corrections are computed for wet conditions, the assumed design criterion used in Table III-1. Design speed is used in calculating downgrade corrections, average running speed in calculating upgrade corrections. The different criteria for descending and ascending grades are based on the effect grades have on the speed of individual vehicles, particularly trucks; the effect these vehicles have on the overall speed of the traffic stream; and the premise that many drivers, particularly those in automobiles, do not compensate completely for the changes in speed caused by grades.

On nearly all roads and streets the grade is traversed by traffic in both directions, but the sight distance at any point on the highway generally is different in each direction, particularly on straight roads in rolling terrain. As a general rule, the sight distance available on downgrades is larger than on upgrades, more or less automatically providing the necessary corrections for grade. This may explain why some design offices do not make corrections in stopping sight distance because of grade. Exceptions are one-way roads or streets, as on divided highways with independent design profiles for the two roadways for which the separate grade corrections are in order and the refinement in design is in keeping with the overall standards used.

Variation for Trucks

The derived minimum sto
car operation and might be q
Trucks as a whole, especially

Exhibit 3

directly reflect passenger
esign for truck operation.
units, require longer stop-

Part I. GENERAL PROVISIONS

1A-1 Purpose of Traffic Control Devices

The purpose of traffic control devices and warrants for their use is to help insure highway safety by providing for the orderly and predictable movement of all traffic, motorized and non-motorized, throughout the national highway transportation system, and to provide such guidance and warnings as are needed to insure the safe and iniformed operation of individual elements of the traffic stream.

Traffic control devices are used to direct and assist vehicle operators in the guidance and navigation tasks required to traverse safely any facility open to public travel.

Guide and information signs are solely for the purpose of traffic control and are not an advertising medium.

1A-2 Requirements of Traffic Control Devices

This Manual sets forth the basic principles that govern the design and usage of traffic control devices. These principles appear throughout the text in discussions of the devices to which they apply, and it is important that they be given primary consideration in the selection and application of each device.

The Manual presents traffic control device standards for all streets and highways open to public travel regardless of type or class or the governmental agency having jurisdiction. Where a device is intended for limited application only, or for a specific system, the text specifies the restrictions on its use.

To be effective, a traffic control device should meet five basic requirements:

1. Fulfill a need.
2. Command attention.
3. Convey a clear, simple meaning.
4. Command respect of road users.
5. Give adequate time for proper response.

In the case of regulatory devices, the actions required of vehicle operators and pedestrians should be specified by State statute, or by local ordinance or resolution which are consistent with national standards. Uniformity of meaning is vital to effective traffic control devices. Meanings ascribed to devices in this Manual are in general accord with the Uniform Vehicle Code of the National Committee on Uniform Traffic Laws and Ordinances, which is the nationally recognized standard in this area.

Five basic considerations are employed to insure that these requirements are met: design, placement, operation, maintenance, and uniformity.

Design of the device should assure that such features as size, contrast, colors, shape, composition, and lighting or reflectorization are combined to draw attention to the device; that shape, size, colors, and simplicity of message combine to produce a clear meaning; that legibility and size combine with placement to permit adequate time for response; and that uniformity, size, legibility and reasonableness of the regulation combine to command respect. Except for symbols on traffic control devices, minor modifications in the design of specific design elements of a device may be necessary, provided that the essential appearance characteristics are met. All symbols must be adopted using the procedures described in Section 1A-6. All symbols shall be unmistakably similar to or mirror images of those shown herein.

I-7(Ed.)
Rev. 5

Placement of the device should assure that it is within the cone of vision of the viewer so that it will command attention; that it is positioned with respect to the point, object, or situation to which it applies to aid in conveying the proper meaning; and that its location, combined with suitable legibility, is such that a driver traveling at normal speed has adequate time to make the proper response.

Operation or application should assure that appropriate devices and related equipment are installed to meet the traffic requirements at a given location. Furthermore, the device must be placed and operated in a uniform and consistent manner to assure, to the extent possible, that vehicle operators can be expected to properly respond to the device, based on their previous exposure to similar traffic control situations.

Maintenance of devices should be to high standards to assure that legibility is retained, that the device is visible, and that it is removed if no longer needed. Clean, legible, properly mounted devices in good working condition command the respect of vehicle operators and pedestrians. In addition to physical maintenance, functional maintenance is required to adjust needed traffic control devices to current conditions and to remove unnecessary traffic control devices. The fact that a device is in good physical condition should not be a basis for deferring needed replacement or change. Furthermore, carelessly executed maintenance can destroy the value of a group of devices by throwing them out of balance. For example, replacement of a sign in a group or series by one that is disproportionately large may tend to depreciate others in the vicinity.

Uniformity of traffic control devices simplifies the task of the road user because it aids in recognition and understanding. It aids road users, police officers, and traffic courts by giving everyone the same interpretation. It aids public highway and traffic officials through economy in manufacture, installation, maintenance, and administration.

Simply stated, uniformity means treating similar situations in the same way. The use of uniform traffic control devices does not, in itself, constitute uniformity. A standard device used where it is not appropriate is as objectionable as a nonstandard device; in fact, this may be worse, in that such misuse may result in disrespect at those locations where the device is needed.

1A-3 Responsibility for Traffic Control Devices

I-7(Ed.) Rev. 5

The responsibility for the design, placement, operation and maintenance of traffic control devices rests with the governmental body or official having jurisdiction. In virtually all States, traffic control devices placed and maintained by State and local officials are required by statute to conform to a State Manual which shall be in substantial conformance with this Manual. Many Federal agencies have regulations requiring standards in conformance with the Manual for their control device applications.

I-8 (c) Rev. 5

The Uniform Vehicle Code has the following provision in Section 15-104 for the adoption of a uniform Manual:

> "The (State Highway Agency) shall adopt a manual and specification for a uniform system of traffic-control devices consistent with the provisions of this act for use upon highways with this State. Such uniform system shall correlate with and so far as possible conform to the system set forth in the most recent edition of the Manual on Uniform Traffic Control Devices for Streets and Highways, and other standards issued or endorsed by the Federal Highway Administrator."

Under authority granted by Congress in 1966, the Secretary of Transportation has decreed that traffic control devices on all streets and highways in each State shall be in substantial conformance with standards issued or endorsed by the Federal Highway Administrator.

1A-3.1 Placement Authority

Traffic control devices shall be placed only by the authority of a public body or official having jurisdiction, for the purpose of regulating, warning, or guiding traffic. No traffic control device or its support shall bear any advertising or commercial message, or any other message that is not essential to traffic control.

Any unauthorized sign placed on the highway right-of-way by a private organization or individual constitutes a public nuisance. All unofficial and nonessential signs should be removed.

With proper authority being given, construction contractors and public utility companies are permitted to erect construction and maintenance signs at work sites to protect the public, equipment, and workers, provided that such signs conform to the standards of this Manual.

PHONE: (703) 754-7236
FAX: (703) 754-9351
E-mail: fred@trc-net.com

2710 LOOKOUT ROAD
HAYMARKET, VIRGINIA 22069

FRED R. HANSCOM, P.E.

Director
Transportation Research Corporation

EXPERIENCE SUMMARY

State and Local Government - Highway Design and Research, 1968-1972
Private Industry - Transportation, Human Factors, and Highway Safety Research, 1973-Present

DISTRICT OF COLUMBIA
MAY -3 AM 9:59

EDUCATION

Bachelor of Science in Civil Engineering
Virginia Polytechnic Institute, 1968

Master of Science in Civil Engineering
Major: Transportation Engineering
West Virginia University, 1970

Ph.D. Program in Transportation Engineering
University of Maryland, Course Work Requirements Completed

WORKSHOPS/ADVANCED STUDIES

Highway Capacity Workshop; Northwestern University, 1971
Transportation Systems Engineering; University of Virginia, 1972
Human Factors Engineering; University of Michigan, 1974
Coordinated Traffic Signal Systems; Georgia Institute of Technology, 1975
Highway Accident Research; National Highway Institute, 1981
Advanced Statistics Workshop; SYSTAT: The System for Statistics; Evanston, Illinois, 1988
Traffic Access and Impact for Site Development; Institute for Transportation Engineers, 1990
Traffic Accident Analysis and Reconstruction; George Washington University, 1990
Motor Vehicle Accident Reconstruction, Society of Automotive Engineers, 1999

PROFESSIONAL MEMBERSHIPS

National Committee on Uniform Traffic Control Devices
Executive Board Member, and *Human Factors and Ergonomics Society* Representative
Transportation Research Board
Committee on Motorist Information Systems
Committee on Methodology for Evaluating Highway Improvements
Technical Review Panel for Truck Size and Weight
Institute for Transportation Engineers, Fellow
Experimental Traffic Control Device Committee
Society of Automotive Engineers
American Society of Civil Engineers
Human Factors and Ergonomics Society
National Forensic Center

REGISTRATION

Licensed Professional Engineer, Virginia and California

EMPLOYMENT

June 1968 to June 1969 - Arlington County Government; Arlington, Virginia

Highway Design Engineer

-Determined alignment of street, curb, and driveway access
-Designed open and closed culvert and pipe storm drainage systems
-Served on select task force to develop utility inventory system

June 1969 to May 1972 - Virginia Highway Research Council; Charlottesville, Virginia

Highway Research Engineer

-Guide sign design and human factors evaluation based on erratic vehicle maneuvers
-Conducted statewide analytic survey of highway signing inventory systems
-Member of special task force to develop remedial measures for accident-prone interchanges
-Participated in engineering evaluations of highway construction zone devices, railway grade crossing warning devices, and reflective delineators

May 1972 to January 1981 - BioTechnology, Inc., Falls Church, Virginia

Senior Transportation Research Engineer

-Directed numerous major research studies evaluating driver/pedestrian behavior
-Emphasis on driver responses to signing and other traffic control devices
-Applied sophisticated roadway instrumentation data collection techniques
-Developed and analyzed driver surveys

January 1981 to Present - Transportation Research Corporation; Haymarket, Virginia

Director

-Conducted major sponsored research in transportation engineering/human factors
-Consulted on numerous highway safety studies
-Provided expert testimony in a variety of traffic safety related cases.

PUBLICATIONS/HONORS

Fifty refereed papers, published in four languages
Institute of Transportation Engineers, National Past Presidents' Award, 1975
Chairman, *Human Factors in Transportation Workshop,* Transportation Research Board, 1995-1996
Who's Who in the South and Southwest, 24th Edition, January 1995-1996
Who's Who in the World, 12th Edition, January 1995-1996

PERSONAL

Marital Status: Single Health: Good
Interests: Computer Technology; Residential Design
Non-professional Accomplishments:

NASTAR ski racing medals (Colorado, Utah; 1986-93)
United States Tennis Association, NRTP Rating: 3.5
Diploma in French Cuisine

SIGNIFICANT TECHNICAL ACCOMPLISHMENTS

Principal Investigator: *Evaluation of Diagrammatic Signing at Capital Beltway Exit No. One* (Project VHRC 71-RP, September, 1971) Conducted at the Virginia Highway Research Council, Charlottesville, VA.

This traffic engineering study determined that benefits of diagrammatic guide signs reduced the incidence of erratic lane changing behavior on the approach to the studied interchange. Recommendations from this study recognized the need for sensitive driver-intrusive sign evaluative techniques, which eventually led to the development of NCHRP Project 3-21.

Staff Consultant: *Traffic Engineering Evaluation of Diagrammatic Guide Signs* (Federal Highway Administration Contract DOT FH-11-7815; 1972). Conducted by BioTechnology, Inc., Falls Church, Virginia

This definitive before/after study of diagrammatic guide sign effectiveness was conducted at seven interchanges and involved extensive traffic operational and driver interview observation procedures. Mr. Hanscom's role involved determination of data collection technique reliability and other traffic engineering input.

Principal Investigator: *Driver Awareness of Highway Sites with High Skid Accident Potential* (Federal Highway Administration Contract DOT-FH-11-7972, 1974). Conducted by Biotechnology, Inc., Falls Church, Virginia

This field study examined driver responses to two types of highway skidding hazard potential; wet pavements subjected to high frictional driving demands, and bridges during periods of possible preferential icing. Study objectives were to examine motorists' general awareness of the hazards and to assess the relative effectiveness of various signing treatments which warn of the hazards. Measures of signing effectiveness were motorists' speeds at critical driving locations and questionnaire responses regarding motorists' hazard awareness and interpretations of the signs.

The portion of this study which evaluated driver response to activated icy-bridge signing won the national, competitive ITE *Past President's Award* in 1975.

Principal Investigator: *Motorist Response to Highway Guide Signs* (National Cooperative Highway Research Program, Project 3-21; 1975). Conducted by BioTechnology, Inc., Falls Church, Virginia

This field study determined and validated guide signing measures of effectiveness (MOEs). Roadside questionnaire responses obtained from a sample of 1,106 motorists performing a variety of vehicle behaviors were used to experimentally assess the sign-relatedness of their vehicle actions. Candidate MOEs included: target vehicle behaviors (visually detectable measures, e.g., erratic maneuvers) and microflow measures of vehicle performance (stream flow parameters, e.g., acceleration noise). Target behaviors included: stopping, weaving over the gore and extension line; driving slowly; following closely; and brakelight indications. Twenty-one microflow measures included: basic flow parameters (e.g., mean speed, headway); flow perturbation measures (e.g., acceleration change); and spot rear-end accident potential (e.g., speed closure rates combined with short headways).

Guide sign MOEs were developed in a series of field experiments, testing their sensitivity across different sites and driving populations. A validation of results was obtained in a before-after study. Four MOEs were found to be: high-risk gore weaves (crossing a through lane in addition to the gore), gore weaves, driving slowly, and lane changes.

Staff Researcher: *Urban Pedestrian Accident Countermeasure Experimental Evaluation* (National Highway Traffic Safety Administration, Contract DOT-HS-190-2-480), conducted by BioTechnology, Inc., Falls Church, VA

This study conducted an empirical evaluation of pedestrian safety countermeasures designed to inhibit undesirable vehicular and pedestrian behaviors. A series of behavioral was conducted in eight major urban areas of the United States. Mr. Hanscom participated in the development of the experimental design, supervised the field data collection, and provided input to the data analysis and final report preparation.

Principal Researcher: *Effects of Truck Size on Driver Behavior* (Federal Highway Administration, Contract DOT-FH-11-9155; 1976), conducted by the Institute for Research, State College, Pennsylvania

This project studied the effects of truck size on the behavior of drivers who interact with trucks in selected roadway situations. Specifically, truck length/configuration was addressed in a freeway entrance merge, mainline lane change, and narrow bridge situations while truck width was studied in a rural two-lane, two-way passing situation. Field work involved the collection of microscopic traffic measures via the Traffic Evaluator System in addition to observations of erratic maneuvers and truck type for the length/configuration studies. Length/configuration had little or no effect on interacting drivers as judged from the data available. The truck/width passing study employed an impedance factor to induce passing of an experimentally widened vehicle. Increasing truck width was found to be conducive to increased prepass headways, reduced lateral distance between passers (overtaking and oncoming) and the truck, and reduced lateral distance between oncomers and the road edge. However, no increases in shoulder encroachments by passers or acceptances of small gaps were found. Mr. Hanscom's role involved contributions to the study design, selecting field study sites and procedures, and supervising field data collection.

Staff Researcher: *Evaluation of Traffic Controls for Highway Work Zones* (National Cooperative Highway Research Program, Project 17-4, 1979). Conducted by BioTechnology, Inc., Falls Church, VA.

Application of channelization devices (i.e., cones, barricades, drums, and panels) was studied to determine their utility in stationary work zones. Device design characteristics were determined in laboratory, closed-field, and highway field settings. A series of human factors and traffic engineering studies developed recommendations for the following device parameters: white-to-orange color ratio, stripe configuration/width, device size/spacing, and reflectivity requirements. Mr. Hanscom contributed to the study design, field site selection, and designation of test devices and field study procedures.

Co-Principal Investigator: *Signing and Delineation for Special Usage (i.e., HOV) Lanes* (Federal Highway Administration Contract DOT-FH-11-9291, 1979). Conducted by BioTechnology, Inc., Falls Church, Virginia

This study applied driver information requirements in the development of signing/pavement marking alternatives. Candidate traffic control device concepts were validated during laboratory testing. Extensive field testing was then conducted in five states. Recommendations consisted of innovative applications of the previously-designated diamond symbol incorporated in a pavement "buffer zone" to delineate HOV usage.

Principal Investigator: *Effectiveness of Changeable Message Displays in Advance of High-speed Freeway Lane Closures* (National Cooperative Highway Research Program, Project 3-21(2), 1980). Conducted by BioTechnology, Inc., Falls Church, VA.

This field study evaluated the effectiveness of changeable message signing (CMS) devices in advance of freeway construction/maintenance zone lane closures. Operational traffic behavior and driver interview data were gathered, nationwide. Before-after studies of baseline (no CMS) versus CMS application consistently demonstrated increased advanced preparatory lane change activity, smoother lane change profiles, significantly fewer late exits (within 100 feet of closure), and reduced speeds at the lane closure point to be associated with CMS use. The most preferable CMS location was found to be 3/4-mile in advance of the lane closures. Device recommendations included sign format (e.g., three-line message) and message content (e.g., speed, lane closure, and merge advisory information). The most effective device consisted of speed advisory and lane closure information.

Principal Investigator: *The Effect of Truck Size and Weight on Traffic Operations* (Federal Highway Administration, Contract DOT-FH-11-8853, 1980), conducted by BioTechnology, Inc., Falls Church, VA.

This field study examined traffic operational effects associated with truck size and weight. Selected highway geometric conditions were: upgrades, downgrades, curves, grade/curve combinations, merge areas, ramps, and urban intersections. Matched weight and operation data were gathered on nearly 6,000 trucks ranging in gross weight from approximately 20,000 to 160,000 pounds. Extensive traffic operations measures obtained via electronic roadway sensors included: flow, perturbations, accident potential, delay, and passing behavior. Three analytical procedures determined: operational differences between truck groupings (e.g., loaded versus empty, single- versus double-trailer combination), correlation between truck characteristics and operation measures, and the predictive effect of truck weight on speed. Findings were: generally reduced speeds, higher deviations from traffic mean speeds, and higher closures with following vehicles, all exhibited by loaded and double-trailer rigs (by comparison with empties and singles, respectively). Higher gross weight was often found to be associated with lower truck speed, poor acceleration performance, and both delay and high closures with respect to following vehicles. Negligible operational effect was associated with truck length.

Consultant: *Geometric Design Requirements in Highway Work Zones* (Federal Highway Administration, Contract DTFH61-80-C-00146, 1980). Conducted by the Midwest Research Institute, Kansas City, Missouri

This project identified safety and operational problems in work zones. Specific safety aspects of concern were truck operations; two-lane, two-way operations on divided highways; reduced lane width effects; and acceptable geometric standards for median cross-overs and pavement/shoulder drop-offs. Mr. Hanscom's involvement included study design inputs, designating study sites, and contributing to the final report preparation.

Consultant/Contributing Writer: *Large Truck Accident Causation* (National Highway Traffic Safety Administration Technical Report HS-806300, July, 1982), Contract No. 6TNH 22-81-P-07668, conducted by the Transportation Research Corporation, Haymarket, Virginia.

This activity involved report writing and limited data analyses relative to environmental and other factors which contribute to large truck accidents.

Developed Training Course: *Deployment and Application of The Traffic Evaluator System* (Federal Highway Administration Contract DTFH61-82-Q-00010, 1982) Conducted by the Transportation Research Corporation, Haymarket, VA.

This activity involved preparation of training materials, conducting a series of classroom sessions, and field training of FHWA personnel to deploy a sophisticated highway data collection device: the Traffic Evaluator System.

Panel Member: *An Investigation of Truck Size and Weight Limits: Panel Review of Final Report*, Office of the Secretary, U. S. Department of Transportation, DOT-05-90086, June, 1982).

Mr. Hanscom was a member of the TRB select panel charged with following progress of the DOT study to examine the need for, and the desirability of, uniformity in maximum truck size and weight limits.

Consultant: *Selection Process for Safety and Operational Improvements on Rural Highways Administered by Local Jurisdictions* (Federal Highway Administration Purchase Order 81-P-00065), Conducted by Wagner-McGee Associates, Alexandria, VA.

This activity involved a literature review and analysis of questionnaire data to assess safety and operational improvement procedures employed by rural county highway agencies.

Principal Investigator: *Improved Techniques for Collection Speed Data* (Federal Highway Administration Contract DTFH61-82-C-00064, completed 1984), conducted by the Transportation Research Corporation, Haymarket, VA.

A series of field studies were undertaken to establish reliabilities associated with a variety of speed collection techniques. Specific activities included: (1) evaluation of vehicle selection strategies, (2) develop manual speed timing techniques, (3) establish suitability of various measurement techniques for various highway types, (4) establish reliabilities associated with various sample sizes, (5) examine speed variation within homogeneous highway sections, and (6) determine a free-flow speed headway criterion.

Consultant: *The Feasibility of a Nationwide Network for Longer Combination Vehicles*, Report of the Secretary of Transportation to the United States Congress (Federal Highway Administration, June 27, 1985). Contract 85- P-80162, conducted by the Transportation Research Corporation, Haymarket, Virginia.

Mr. Hanscom and TRC support staff conducted an extensive literature review addressing specific aspects of large truck operations. The findings of this literature review were incorporated into the large truck network feasibility study.

Principal Investigator: *Field Test of the Grade Severity Rating System* (Federal Highway Administration, Contract DTFH61-82-C-00093, 1982). Completed 1985; conducted by Transportation Research Corporation, Haymarket, Virginia.

This field study tested the effectiveness of weight-specific signing (WSS) to elicit speed reductions of heavy trucks on long downgrades. A secondary M.O.E. was incidence of smoking brakes. A five-state study, conducted at control and test sites, demonstrated WSS effectiveness at steep downgrades (e.g., 6 percent for 5 miles). Recommendations for state application of weight-specific signing also considered favorable liability implications associated with its use.

Consultant: *Inexpensive Countermeasures at Narrow Bridges* (Federal Highway Administration Contract DTFH61-83-C-00148). Conducted by Goodell-Grivas, Inc., Southfield, MI.

This study evaluated a variety of post-mounted delineator and pavement marking applications to increase operation safety at narrow bridges. Mr. Hanscom's role was to designate data collection procedures.

Consultant: *Survey of Heavy Truck Conspicuity Enhancements* (National Highway Traffic Safety Administration Contract DTNH22-84-R-07080). Conducted by The Allen Corporation of America, Alexandria, VA

This field study examined conspicuity-related attributes of truck trailers as an accident-prevention countermeasure. In preparation for NHSTA's recommendation for federal legislation requiring reflective rear trailer enhancements (e.g., reflectorized material strips), a survey was conducted of trucks under day and night operating conditions in various east coast locations. Mr. Hanscom's role in the study was to develop field survey procedures and to supervise a pre-test of the developed protocol.

Consultant: *The Operation of Larger Trucks on Roads and Streets with Restrictive Geometry* (Federal Highway Administration Contract DTFH61-84-C-00043). Conducted by Goodell-Grivas, Inc., Southfield, MI.

This field study examined the operation of specific truck characteristics allowed by the Surface Transportation Assistance Act of 1982 under specific urban and rural roadway conditions. Mr. Hanscom's role was to assist in the selection of study sites, designation of data collection techniques, analysis of results, and preparation of the final report.

Principal Investigator: *Service Vehicle Lighting and Traffic Control Systems for Short-term and Moving Work Zones* (National Cooperative Highway Research Program Project 17-6A). Completed 1988; conducted by the Transportation Research Corporation, Haymarket, Virginia.

This study consisted of laboratory, closed field, and highway field studies to develop traffic control systems which are most effective for certain types of highway maintenance activities. Project activity involved analysis of driver information requirements, laboratory determination of traffic control device characteristics to best meet those requirements, and device testing in controlled test-track and actual highway settings to determine best performing devices. The product of this project was a set of traffic control guidelines designating recommended device practices under appropriate operational conditions.

Principal Investigator: *Effectiveness of Truck or Roadway Lane Restriction* (Federal Highway Administration Contract DTFH61-85-C-00082). Completed in 1989; conducted by the Transportation Research Corporation, Haymarket, Virginia.

Both operational and accident safety effects of restricting trucks from designated roadway lanes were examined in this five-state study. Before-after operational effects of lane restrictions were determined for three sites; traffic flow-related M.O.E.s were truck compliance to the restriction, the proportion of trucks impeding other traffic, and speed/density characteristics of other vehicles impeded by trucks. New lane restrictions were implemented in the Chicago, Illinois, and Madison, Wisconsin, sites in cooperation with this study. Findings indicated benefits of the implemented truck lane restrictions included compliance with the restriction signing and less traffic congestion associated with truck presence.

Co-Principal Investigator: *Fundamental Studies of Speed Zoning and Control* (Federal Highway Administration Contract DTFH61-85-C-00136). Study completed 1991; conducted by Martin Parker and Associates, Wayne, Michigan.

This nationwide study examined motorist response to posted speed limit changes in 23 states. In addition, a driver questionnaire was developed and pre-tested to determine driver attitudes regarding speed limit compliance. Mr. Hanscom's role was to develop the questionnaire and to supervise a portion of the speed data collection.

Principal Investigator: *Effect of the 65-mph Speed Limit* (Insurance Institute for Highway Safety, Project 7049), 1987. Conducted by the Transportation Research Corporation.

Multi-state speed data collection to examine effect of increased speed limit. This activity involved establishing data collection equipment reliability.

Consultant: *Truck Accidents at Freeway-to-freeway Connectors* (Sponsored by the California State Department of Transportation). Study completed in 1990; conducted by the Institute of Transportation Studies at the University of California, Irvine.

This study examined truck accident causation on major connector ramps. Recommendations were developed for (1) revising geometrics, (2) appropriate warning signs, (3) and revised design standards. Mr. Hanscom provided input to the accident typology study, supervised collection of truck speed/trajectory data at selected connectors in the Los Angeles area, and provided input to the final report.

Consultant: *Safety of Wider Trucks on Narrow Roadways* (Federal Highway Administration Contract DTFH61-87-Z-00077). Study completed 1990; conducted by Analysis Group Inc., Washington, D.C.

This field study addressed operational differences of a variety of truck length/width combinations and associated behaviors of other traffic under specific highway geometric conditions. Mr. Hanscom's role was to work with Highway Safety Research Center staff at the University of North Carolina in developing study procedures.

Principal Investigator: *Assessment of Applied Speed Monitoring Procedures* (California Department of Transportation Contract 51H416). Completed 1989; conducted by the Transportation Research Corporation. Haymarket, Virginia

This study addressed the representativeness of data obtained using state speed monitoring procedures. Specific measurement issues which were addressed include: speed variation within homogeneous roadway monitoring sections, monitoring equipment reliability, and site selection procedures.

Principal Investigator: Subcontract to *Analysis of Speed and Other Unsafe Driving Acts* (National Traffic Safety Administration, Contract Number NRD-010-9-07306, 1989). Study completed in 1990; conducted by the Transportation Research Institute, University of Michigan.

This study examined the association between speed and other specific vehicle behaviors leading to fatal and serious crashes. The objective was to identify speed enforcement strategies to eliminate other behaviors contributing to crashes. Mr. Hanscom's role was to provide input to the overall safety study design and to design a multi-state field observational study.

Principal Investigator: Subcontract to *Maintenance Work Zone Safety Devices Development and Evaluation* (National Research Council, Strategic Highway Research Program, Contract H-109) Study completed in 1993; conducted by Ensco, Inc., Springfield, Virginia.

This study evaluates and tests a variety of innovative traffic control devices designed to protect workers in highway maintenance/construction zones. Tested device concepts include: barrier design, vehicle encroachment alerting devices, rumble strips, delineation, vehicle rear-end lighting devices, signs, and flagging techniques.

Mr. Hanscom's role was to provide input to the study design and to conduct test tract and open field evaluative studies of selected devices.

Principal Investigator: Subcontract to *Retroreflective Highway Sign Inspection System* (Howard County, Maryland Contract CA-90-47) Study completed 1991; conducted by Kidde Consultants, Inc., Baltimore, Maryland.

This study examined the state-of-the-art in retroreflective sign luminance measurement and automated sign inventory techniques. Current techniques are then applied to develop and test a highway sign inventory system for implementation by Howard County, Maryland. Mr. Hanscom was involved in all phases of activity.

Technical Advisor: *Maintenance Worker Training and Implementation Products* (National Research Council, Strategic Highway Research Program, Contract H-110) Activity completed in 1991; conducted by Roy Jorgensen Associates, Inc., Buckeystown, Maryland

This project produced communications and training products to facilitate implementation of innovative work zone warning devices developed in previous Strategic Highway Research Program developmental efforts. Mr. Hanscom's role was to consult in the preparation of training videotapes advising state highway agencies on the proper application of newly developed work zone devices.

Consultant: *Human Factors Project Administrative and Technical Support to the Federal Highway Administration* (Federal Highway Administration Contract DTFH61-91-C-00099) Study completed September, 1992; under contract to Science Applications International Corporation, McLean, Virginia

This project provides personnel required to conduct various technical activity at the Federal Highway Administration, including operation of their human factors laboratories and preparation of Requests For Proposals. Mr. Hanscom provided expertise in highway engineering for a variety of technical activity. His activity included evaluation of contractor research proposals.

Consultant: *Crash Avoidance Research Technology - Field Data Collection* (National Traffic Safety Administration Contract DTNH22-92-D-07002) 1992 Study under contract to Dynamic Sciences, Annapolis, Maryland

This activity supports NHTSA's crash avoidance research effort to collect and analyze roadside observational and crash data for the purpose of development and evaluation of specific safety measures, e.g., antilock brakes, vehicle lighting, automobile displays. Mr. Hanscom was designated to provide traffic and human factors engineering expertise.

Consultant: *Traffic Control Videotape Development for the International Road Federation* Activity in progress; conducted by Roy Jorgensen Associates, Inc., Buckeystown, Maryland

This project involved the preparation of ten educational videotapes in the areas of traffic control signs, markings, islands, and highway work zone safety. The purpose of the videotape is to educate engineers around the world regarding the state-of-the-art in selected traffic control and safety techniques. Mr. Hanscom's role involved preparation of the technical basis for script preparation and provision of on-site technical support during shooting.

Principal Investigator: *Full-scale Vehicle Crash Testing of Robotic STOP/SLOW Paddle Support for Use in Highway Work Zones.* Activity completed in August, 1993; conducted by the Transportation Research Corporation, under contract to Quintech Electronics and Communications, Inc., Indiana, Pennsylvania.

This project involved full-scale vehicle crash testing of a remotely controlled robotic support stand for highway work zone STOP/SLOW paddle. The intent of this device is to reduce accident exposure for flag personnel. Testing was conducted in accordance with NCHRP Project 22-2, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*. The objective of the crash test was to determine: (1) whether the tested device would damage an errant vehicle intruding into the work zone and striking the device, and (2) whether the device or fragments therefrom would injure a highway construction zone worker in a crash situation.

Principal Investigator: *Developing Measures of Effectiveness for Truck Weight Enforcement Activities* (National Research Council, National Cooperative Highway Research Program Project 20-34). Project initiated January 1, 1994 and was completed in 1997. Conducted by Transportation Research Corporation, Haymarket, Virginia.

The objective of this project was to develop and validate measures of effectiveness (M.O.E.s) for truck weight enforcement programs. This five-state, nation-wide study involves assessing data collection capabilities of state highway agencies for their suitability for M.O.E. application. The product of this research was a software package comprising guidelines for states to apply in determining the effectiveness of their truck weight enforcement activities. The software is currently maintained for distribution via TRC's web site.

Principal Investigator: *Guide Sign Design at Vail, Colorado Roundabout Interchange.* Under contract to Leif Ourston and Associates, Santa Barbara, California. Project completed July, 1995.

Mr. Hanscom's role in the development of roundabout interchanges at Vail, Colorado was to design the guide signs in accordance with accepted practice, with special consideration to the unique driver task imposed by a predominantly U.S. tourist driver sample encountering a European interchange design.

Consultant: *Determine Causes of Driver Maneuver Errors* Federal Highway Administration Contract DTFH61-96-C-00015. Conducted by COMSIS Incorporated, Silver Spring, Maryland. Study completed in 1998.

The objectives of this study are: (1) to identify and classify environmental and vehicular cues which drivers use to initiate maneuvers and assess how individual differences in driver perception of their own driving abilities effect their response to those cues, (2) determine driver ratings of their driving abilities and driving performance, and (3) develop driver decision-making parameters that can be incorporated into current FHWA modeling efforts. Mr. Hanscom's role was to assist in the literature review and data collection activities.

Consultant: *Human Factors Study of Traffic Control in Highway Construction and Maintenance Zones.* FHWA Contract Number DTFH61-95-C-00064, conducted by Performance, Safety, and Health Associates, State College, Pa. Activity completed in 1996.

The purpose of this project was to identify human factors deficiencies with existing work zone traffic controls and to develop traffic control device remedies. The product of this research will be guidelines to be incorporated into the national *Manual of Uniform Traffic Control Devices.* Mr. Hanscom's role in this project was to oversee all project activities, i.e., develop human factors guidelines, structure and supervise field data collection and analysis, and prepare reports.

Consultant: *Delineation of Hazards for Older Drivers* Federal Highway Administration Contract DTFH61-92-C-00043 Conducted by COMSIS Incorporated, Silver Spring, Maryland. Activity completed May, 1996.

This project developed and tested a number of traffic control devices designed to improve driving safety for older drivers. Mr. Hanscom's role was to conduct a benefit-cost analysis of object markers.

Principal Investigator: *Field Evaluation of the Collision Countermeasure System (CCS) for an Unsignalized Intersection* Federal Highway Administration Contract DTFH61-94-C-00131, Subcontract, to prime contractor E-Systems, A Raytheon Company. Project completed in December 1998.

Mr. Hanscom conducted a field evaluation of an automated vehicle-detection and changeable-message sign system designed to warn major-road drivers of approaching minor-road vehicles. TRC designed the study based on measures of accident potential, i.e., time-to-collision and vehicle conflict occurrences. TRC staff collected data, performed the analysis, and prepared a report.

Consultant: *Human Factors in Highway Work Zones*, Ministry of Transportation, Ontario, Canada. Project under contract to Human Factors North, Toronto, Ontario. Activity in progress.

The objective of this project is to identify traffic control areas for potential improvement and to develop appropriate accident countermeasure concepts.

Principal Investigator: *Further Field Evaluation of the Collision Countermeasure System (CCS) in Prince William County, Virginia.* Continuation of work initiated under Federal Highway Administration Contract DTFH61-94-C-00131. Under contract to Transportation Research Corporation; Virginia Department of Transportation. Activity in progress.

Mr. Hanscom is conducting a field evaluation of an automated vehicle-detection and changeable-message sign system designed to warn major-road drivers of approaching minor-road vehicles. TRC designed the study based on measures of accident potential, i.e., time-to-collision and vehicle conflict occurrences. TRC staff is continuing data collection and analysis. The current effort includes a benefit-cost study.

PUBLICATIONS AND PAPERS

Hanscom, F.R. *The effects of diagrammatic signing at Capital Beltway Exit One.* (Master's Thesis, West Virginia University, 1971), Virginia Highway Research Council, Charlottesville, Virginia, September, 1971.

Hanscom, F.R. *An analytic survey of highway signing inventory systems in Virginia.* Virginia Highway Research Council, Charlottesville, Virginia, May, 1972. (Abridgment, *Highway Research Record 445,* 1973)

Hanscom, F.R. Evaluation of diagrammatic signing at Capital Beltway Exit One. *Highway Research Record 414,* 1972.

Hanscom, F.R. *Discussion of 'Development of a Driver-Information-Acquisition Based Operation Tool for the Evaluation of Highway Signs,'* by T.H. Rockwell and V. Bhise. *Highway Research Record 440,* 1973.

Hanscom, F.R. An evaluation of diagrammatic signing using time-lapse photography. *Society of Photo-optical Instrumentation Engineers Proceedings No. 37,* Society of Photo-optical Instrumentation Engineers, Redondo Beach, CA, 1973.

Hanscom, F.R. *Driver awareness of highway sites with high skid accident potential.* Report FHWA-RD-74-66. Federal Highway Administration, Washington, D.C., July, 1974.

Berger, W.G., & Hanscom, F.R. *Motorist response to highway guide signing.* Phase I Report, NCHRP Project 3-21, BioTechnology, Inc., Falls Church, Virginia, 15 August 1974.

Hanscom, F.R. An evaluation of signing to warn of potentially icy bridges. *Transportation Research Record 531,* 1975.

Hanscom, F.R. An evaluation of icy bridge warning signs.* *Institute of Traffic Engineers. 45th Annual Meeting Compendium, 1975.* (Abridgment, *Traffic Engineering, Volume 45, No. 9)* Japanese Translation, *Expressways and Automobiles,* Express Highway Research Foundation, Tokyo, Japan, March, 1976.

Hanscom, F.R., & Berger, W.G. *Vehicle behavior at one interchange related to driver guide sign responses.* Paper presented at the 55th Annual Meeting of the Transportation Research Board, Washington, D.C., 1976.

Roberts, J.M., Hutchinson, J.W., & Hanscom, F.R. *Driving behavior and self-testing attitudes.* Paper presented at the 55th Annual Meeting of the Transportation Research Board, Washington, D.C., January, 1976.

Hanscom, F.R. An evaluation of signing to warn of wet weather skidding hazard. *Transportation Research Record 600.* Transportation Research Board, National Research Council, Washington, D.C. 1976

Hanscom, F.R., & Berger, W.G. *Motorist response to highway guide signing. Volume I. Field evaluation of measures. Final Report.* Prepared by BioTechnology, Inc., for the National Cooperative Highway Research Program (Project 3-21), Washington, D.C., 31 January 1976.

Schmitz, P.R., Berger, W.G., & Hanscom, F.R. *Motorist response to highway guide signing. Volume II. Analysis procedure and output. Final Report.* Prepared by BioTechnology, Inc., for the National Cooperative Highway Research Program (Project 3-21), Washington, D.C., 31 January 1976.

*Received Institute of Transportation Engineers Past President's Award, 1975.

Seguin, E.L., Hanscom, F.R., Harrison, P.C., & Hostetter, R.S. *Effects of truck size on driver behavior, Interim Report. Synthesis of researchable car-truck interactions.* Contract No. DOT-FH-11-9155. Prepared by the Institute for Research, Inc., for the Federal Highway Administration, Washington, D.C., 1976.

Sanders, J.H., Berger, W.G., & Hanscom, F.R. The traffic evaluator system: An innovative data collection tool. *Public Roads, Volume 40, No. 9.* U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., March, 1977.

Hanscom, F.R. *Human factors in skidding: Causation and prevention.* Paper presented at the Second International Skid Prevention Conference, Columbus, Ohio, May, 1977. Also published in *Transportation Research Record 623,* 1977.

Hanscom, F.R. *Driver awareness of wet weather skidding accident potential* (abridgment). Ancillary paper published in the proceedings of the Second International Skid Prevention Conference, Columbus, Ohio, May, 1977. Also published in *Transportation Research Record 624,* 1977.

Hanscom, F.R., & Berger, W.G. Evaluating highway guide signing (abridgment). *Transportation Research Record 667,* 1978.

Hanscom, F.R. *Data collection procedures for truck exposure,* Proceedings of the National Symposium on Commercial Truck Exposure, Washington, D.C., April, 1979.

Hanscom, F.R. *Evaluation of guide sign M.O.E.s.* Proceedings of the International Symposium on Traffic Control Systems. Volume 2. Institute of Transportation Studies, University of California, and the Federal Highway Administration, Washington, D.C., December, 1979.

McGee, H.W., & Hanscom, F.R. *Selection process for safety and operation improvements on rural highways administered by local jurisdictions: A preliminary assessment.* Prepared by Wagner-McGee Associates, Inc., for the Federal Highway Administration, Washington, D.C., March, 1981.

Vallette, G.R., & Hanscom, F.R. *The effect of truck size and weight on accident experience and traffic operations. Volume I. Executive Summary.* Report No. FHWA/RD-8/135. Federal Highway Administration, Washington, D.C., July, 1981.

Hanscom, F.R. *The effect of truck size and weight on accident experience and traffic operations. Volume II. Traffic Operations.* Report No. FHWA/RD-80/136. Federal Highway Administration. Washington, D.C., July, 1981.

Hanscom, F.R. *Effectiveness of changeable message displays in advance of high-speed freeway lane closures.* NCHRP Report 235. National Cooperative Highway Research Program. Transportation Research Board, National Research Council, Washington, D.C., September, 1981.

Hanscom, F.R. Effectiveness of changeable message signing at freeway construction site lane closures. *Transportation Research Record 844.* National Academy of Sciences, Washington, D.C., 1982.

Pain, R.F., Knapp, B.G., & Hanscom, F.R. *Signing and delineation for special usage lanes. Volume III. Field evaluations and implementation suggestions.* Contract DOT-FH-11-9291. Report No. FHWA/RD-81/064. Federal Highway Administration, Washington, D.C., January, 1982.

Pain, R.F., Hanscom, F.R., & McGee, H.W. *Work site traffic controls in the U.S.: existing and new technologies. Traffic Engineering and Control, Volume 24, No. 10.* Printerhall Limited, London, England, October, 1983.

Larson, E.E., & Hanscom, F.R. *Traffic operational impact of large trucks: a literature review.* Prepared by the Transportation Research Corporation for Transportation and Socio-Economic Division, Federal Highway Administration, Washington, D.C., October, 1984. Also published in *ITE Compendium of Papers, 1985 Annual Meeting of the Institute of Transportation Engineers, Washington, D.C., 1985.*

Hanscom, F.R. *Improved techniques for collection speed data.* Report DTFH61-82-C- 00064. Federal Highway Administration, Washington, D.C., November, 1984.

Hanscom, F.R. *Field Test of the Grade Severity Rating System.* Final Report. FHWA Contract DTFH-82-C-00093. Report No. FHWA/RD-86/011. Federal Highway Administration, Washington, D.C. September, 1985.

Zegeer, C.V., Hummer, J.E., & Hanscom, F.R., *The Operation of Large Trucks on Restrictive Geometry*. FHWA Contract DTFH61-84-C-00043. Report No FHWA/RD-86/157. Federal Highway Administration, Washington, D.C., July, 1986.

Hanscom, F.R., Validation of a Non-automated Speed Data Collection Methodology. *Transportation Research Record 1111.* Transportation Research Board, National Research Council, Washington, D.C., 1987.

Hanscom, F.R. Weight-specific Highway Sign Effects on Heavy Trucks. *Transportation Research Record 1114.* Transportation Research Board, National Research Council, Washington, D.C., 1987.

Hummer, J.E., Zegeer, C.V., & Hanscom, F.R., Effects of Turns by Larger Trucks at Urban Intersections. *Transportation Research Record 1195.* Transportation Research Board, National Research Council, Washington,D.C., 1988

Pain, R.F. & Hanscom, F.R. Warning Lights on Service Vehicles in Work Zones. *Proceedings of the Strategic Highway Research Program and Traffic Safety on Two Continents in Gothenburg, Sweden, 27-29 September, 1989.* Swedish Road and Traffic Research Institute, Linkoping, Sweden, 1989

Hanscom, F.R. Feasibility of an Alternative Shuttle Bus System to Reduce Curbside Traffic Congestion at the Los Angeles International Airport. *Transportation Research Record 1273.* Transportation Research Board, National Research Council, Washington, D.C., 1990

Hanscom, F.R. Operational Effectiveness of Three Truck Lane Restrictions. *Transportation Research Record 1281.* Transportation Research Board, National Research Council, Washington, D.C., 1990

Zegeer, C.V., Hummer, J., & Hanscom, F.R. Operational Effects of Trucks on Rural Roadways. *Transportation Research Record 1281.* Transportation Research Board, National Research Council, Washington, D.C., 1990

Hanscom, F.R. & Pain, R.F. *Service Vehicle Lighting and Traffic Control Systems for Short Term and Moving Work Zones.* NCHRP Report 337, National Cooperative Highway Research Program, National Academy of Sciences, Washington, D.C., January 1991

Hanscom, F.R. Closed Track Testing of Maintenance Work Zone Safety Devices. *Proceedings of the Strategic Highway Research Program and Traffic Safety on Two Continents* Gothenburg, Sweden, 18-20 September, 1991. Swedish Road and Traffic Research Institute, Linkoping, Sweden, 1991

Stout, D., Graham, J, & Hanscom, F. *Maintenance Work Zone Safety Devices, Development and Evaluation.* Final Report, Project SHRP-109, Strategic Highway Research Program, Washington, D.C., 1993

Hanscom, F.R. Highway Evaluation of Maintenance Work Zone Safety Devices. *Proceedings of the Strategic Highway Research Program (SHRP) and Traffic Safety on Two Continents,* Hague, Netherlands, 22-24 September, 1993. Swedish Road and Traffic Research Institute, Linkoping, Sweden, 1993

Hanscom, F.R. Highway Agency Preliminary Implementation of Maintenance Work Zone Safety Devices, *Proceedings of the Strategic Highway Research Program and Traffic Safety International Conference*, Prague, The Czech Republic, 20-22 September, 1995; and *Proceedings of the International Forum on Road Research Safety*, Bangkok, Thailand, 25-27 October, 1995; Swedish National Road and Transportation Institute, S-581 95, Linkoping, Sweden, 1996

Hanscom, F.R. Measures of Effectiveness (M.O.E.s) of Truck Weight Enforcement *Proceedings of the 1996 National Traffic Data Acquisition Conference*, Alliance for Transportation Research, Albuquerque, New Mexico, 5-9 May, 1996

Lerner, N.D.; Benel, D.; Huey, R.W.; Hanscom, F.R.; & Steinberg, G.V. *Driver Maneuver Errors: Research Plan,* Contract DTFH61-96-C-00015, Federal Highway Administration, Washington, D.C., November 1996

Hanscom, F.R. *Developing Measures of Effectiveness for Truck Weight Enforcement* Draft Phase I Final Report, NCHRP Project 20-34, Submitted to the National Cooperative Highway Research Program, National Research Council, Washington, D.C., January 1997

Hanscom, F.R. *Truck Weight Enforcement: Measures of Effectiveness (M.O.E.s)* Invited paper, Presented to the AASHTO Standing Committee on Research, November 18, 1997, AASHTO Annual Meeting, Salt lake City, Utah, American Association of State Highway and Transportation Officials, Washington, D.C.

Hanscom, F.R. and Goelzer, M.W. Truck Weight Enforcement Measures of Effectiveness: Development and Software Application, *Transportation Research Record 1643,* Transportation Research Board, Washington, D.C., 1998

Hanscom, F.R. Truck Weight Enforcement M.O.E. User Guide *Proceedings of the 1998 North American Travel Monitoring Exhibition and Conference*, Institute for Transportation Research and Education, North Carolina State University, Raleigh, North Carolina, 5-9 May, 1998

Hanscom, F.R. *Vehicle Behavioral Evaluation of the Collision Countermeasure System (CCS)* Federal Highway Administration Contract DTFH61-94-C-00131, Final Report submitted to Raytheon Company, Falls Church, Virginia, December 1998

Hanscom, F.R. Experience with a Collision Countermeasure System at a Rural, Stop-Controlled Intersection in Prince William County. Invited paper, presented at the *1999 Annual Conference on Transportation Safety*, Sponsored by the Virginia Department of Transportation, May 5, 1999, Norfolk, VA

Lerner, N.D., Steinberg, G.V., Huey, R.W., and Hanscom, F.R. *Understanding Driver Maneuver Errors,* Final Report, Contract DTFH61-96-C-00015, Federal Highway Administration, Washington, D.C., July 1999

Hanscom, F.R. *Human Factors Issues in the Manual on Uniform Traffic Control Devices,* Invited paper, presented at the 69th Annual Meeting of the Institute of Transportation Engineers, Washington, D.C., August 1999

Hanscom, F.R. *Rural Stop-sign Controlled Intersection Accident Countermeasure Device - - A Behavioral Evaluation,* To be published in the Proceedings of the 10th Annual Meeting of the Intelligent Transportation Society of America, Washington, DC, May 2000

Dewar, R.E and Hanscom, F.R. Book Chapter: *Human Factors in Work Zone Design* in *Human Factors in Traffic Safety,* Lawyer's and Judges Publishing Company, Tucson, AZ; Forthcoming publication.

Lerner, N.D., Steinberg, G.V., Huey, R.W., and Hanscom, F.R. *Driver Misperception of Maneuver Opportunities and Requirements,* Paper presented at the Human Factors and Ergonomics Society Annual Meeting, Santa Monica, CA, July 2000

Hanscom, F.R. Book Chapter: *Human Factors* in *Traffic Control Devices Handbook, A Supplement to the Manual on Uniform Traffic Control Devices*, Institute of Transportation Engineers, Washington DC; Forthcoming publication, 2001.