

## **Problem Statement and Work Plan for the Research and Design of a Comprehensive Systematic Upgrade for Road Guidance Signs and the Engineering Basis for Regulatory and Warning Signs**

### **Phase I: Upgrade for Road Guidance Signs**

#### **Problem Statement and Program Objectives**

The complexity of the highway environment and the demands placed on the system and its users have increased exponentially over the years, far outpacing the slow evolution of standards for sign legibility and layout. Although there have been ongoing improvements in highway geometric design in response to these growing demands and the expanding volume of traffic in the system, the only notable changes in signing have been the development of higher brightness materials and two MUTCD amendments: the reduction in the legibility index from 50 to 40 ft/in; and the optional use of mixed-case copy on conventional road guide signs and street name signs. There has been no research to determine the legibility of the newly introduced lowercase letters for Standard Alphabet Series B, C, D, E, and F. There are no consistent design standards for typeface selection or layout of regulatory and warning signs. There are no engineered minimum legibility standards for these negative contrast signs. Further, although it has been known for over a decade that the existing FHWA Standard Alphabets perform poorly in black when displayed with high brightness white, yellow, and orange background sheeting materials (e.g., Mace, Garvey, and Heckard, 1994), there has been no attempt to remedy this.

A proposed system-wide upgrade will specifically and comprehensively resolve these and many additional shortcomings. Building on recent work to create a proportional grid system for guide sign formats (Meeker, Pietrucha, and Garvey, 2006 and 2007 [anticipated; undergoing a second review]), the objective is to develop truly uniform, all-inclusive sign standards that meet the multifaceted and evolving needs of the modern highway and urban environment for driving. These designs evolve from the existing standards with appropriate refinements based on a comprehensive program of research and development. The new standards will result in accurate proportions for key sign and sign element dimensions enhancing driver performance and safety by improving the consistency and readability of all sign types for all current and projected roadway applications. These recommendations will also be efficient to administer, and the logical, systematic approach to highway sign design, material management, and documentation will reduce overall sign management program costs.

#### **Work Plan**

##### **Guide Sign Standards Analysis, and Conventional Road Scale and Freeway Scale Legibility Studies**

An upgrade such as that proposed requires a thorough understanding of sign design components and their interaction and an extensive appreciation of how highway users

read signs. To achieve these goals, a series of research studies is proposed, beginning with an investigation into fundamental sign elements, followed by the establishment of baseline legibility and recognition indices for positive contrast versions of Clearview and the Standard Alphabets. This will enable the research team to refine and validate all aspects of the aforementioned proportional grid guide sign system, which uses a common mathematical relationships based on “X” for which “X” is the height of the lead capital letter of the primary legend. This will result in uniform legend size standards for each respective roadway classification (based on a review of roadway classifications in response to evolving changes in the American roadscape), proper sizes and formats for arrows, optimal formatting for cardinal directions, appropriate route shield size, minimum border sizes, minimum space relative to legend and background, and line-to-line relationships for mixed case legends, etc. The culmination of this design and research program will be specific recommendations to systematically upgrade the relevant sections of the MUTCD.

### **Guide Sign Research and Design Upgrade**

This research would begin with a complete review of current guide sign standards, paying particular attention to the organization and design of visual elements and overall sign layout. This review would include an examination of existing and projected guide sign applications taking into consideration current roadway design (freeway and conventional road), interrelationships of various sign types used in proximity to these signs, modern retroreflective sheeting materials, typographic improvements, older driver needs, and up-to-date sign production methods. The guide sign evaluation will also uncover any discrepancies in guidance that exist in the MUTCD relative to legibility indices, borders, legend-to-background relationships, arrow design and placement, cardinal directions, and route shield size, as well as any guidelines used by states that is not part of the MUTCD or SHS standards. Current guidance will be compared to the state-of-practice, and a uniform, proportion-based system for the display of motorist guidance will be developed. Human factors research will be conducted on an as-needed basis to prepare scientifically rigorous, field-validated recommendations for specifications and implementation. This includes studies of the graphic components of a sign and the sign as a composite graphic.

### **Research Activities for the Phase I Study**

In the initial stages of the study the research team will compare existing practice in participating states for each respective sign function and identify applications that are commonly used with some effectiveness by a participating state, but are not part of the guidance given by the MUTCD. The research team will also identify how road classification may impact signing. When applicable, the team will trace the history of the state standards and guidelines to understand their evolution.

There will also be an editorial review of the description of standards relative to content and alternative approaches will be identified to improve clarity and ease of understanding and use.

Based on the results of these tasks, conventional road guide sign studies will be conducted by PTI with freeway applications being studied by TTI. These human factors studies will build upon prior work by the Pennsylvania Transportation Institute (PTI) and the Texas Transportation Institute (TTI) to study guide sign recognition and legibility while incorporating a comprehensive analysis of type weight in the hierarchy of weights and letter space.

The testing of both conventional road and freeway sign applications will go beyond merely studying the recognition and legibility of destination names. The effective use of elements such as route shields, cardinal directions, and arrows will also be evaluated. The overall arrangement of these elements will be based on the proportional grid system developed by Meeker, Pietrucha, and Garvey (2006 and 2007). The research will employ complete signs assemblies and the systematic variation of design elements in full scale to identify optimal arrangements.

Each component will be isolated for study and optimization. Within this phase the study team will propose recommendations to improve glance comprehension and overall layout of guide signs for consistency.

Sample study tasks will include:

- Determining the X height for the target words for different categories of road
- Establishing minimum and optimal figure field relationships for conventional road guide signs as used in limited shoulder carriageways and in urban applications not addressed in the current MUTCD
- Determining the appropriate route shield size for all classes of road and applications
- Developing a common route shield panel system (function of route shield, arrow, cardinal direction)
- Updating prior PTI arrow study (Garvey, Chirwa, Meeker, Pietrucha, Zineddin, Ghebrial, and Montalbano, 2004) and reviewing designs based on specific applications
- Validating prior PTI cardinal direction word study and reviewing designs based on specific applications
- Studying, validating, and refining options for action words in both all upper and mixed case
- Identifying the proper footprint and alignment of the numerator and the denominator and relationship to primary number for Clearview fractions
- Determining the appropriate border size as a proportion of X for all primary applications
- Analyzing the Clearview 6-W font to determine proper use for bifurcated lane applications
- Studying, validating, and refining options for gore sign
- Studying the design and location of arrow, size of arrow, and relationship to shield, cardinal direction, and layout for exit signs
- Analyzing the appropriate size for exit sign panels
- Identify standard approaches to make mixed case displays (with descending letters) more readable with smaller panels and allow for size based on category of road for street name signs.

## **Phase II: Engineering Basis for Regulatory and Warning Signs and Program Documentation**

### **Engineering Basis for Regulatory and Warning Signs**

In a parallel effort, to be funded after the initial study described above is completed, the team will chart the content of the MUTCD and SHS book to identify any discrepancies and shortcomings in these documents and determine how varying sizes and methods of regulatory and warning sign messaging may increase readability and sign understanding and reduce ambiguity with signs having similar messages or a common look but a different message. Human factors researchers from the study team will identify the legibility indices and display requirements for these negative contrast typeface applications through controlled field experiments. Variables include: font weight selection, letterspace and word space, size, layout and word grouping, combinations of words and symbols, figure-field relationships/minimum border, chunking and use of message groups, panel orientation, and appropriate use of mixed case or all upper case. With the resulting baseline legibility and comprehension research data, these sign types could be improved to communicate more consistently and safely with roadway users, and the number of sign size options would be reduced resulting in more efficient sign management programs. The end result will be a recommended approach to replace or improve the current standards, which consist of hundreds of applications, with a more ordered approach to management and design based on solid engineering and ergonomic criteria for sign design and with a systematic use of material sizes where possible.

### **Program Documentation**

For the research to be translated into practical tools to aid highway and traffic engineers improve the quality of traffic control devices on all categories of road there are several post research products that must be developed. These products would include: precise recommendations on design of signs to help affirm a more uniform standard based on sound design and research, development of a refined approach to standards documentation based on design criteria and messaging standards, a recommended approach to the applicable chapters of the MUTCD, and work with the appropriate federal authorities and advisory committees to share the work of the design team. This comprehensive approach is designed to streamline the disjointed method in which recommendations are made to the standards. By providing a detailed blueprint that reflects the research and design program, the overall guidelines will be consistent and comprehensive. The formats proposed will afford efficient use by participating states using current technologies. To realize these ends, the following documentation tasks would be undertaken:

- Prepare documented recommendations for appropriate sections of the manual including but not limited to 1A, 2B, 2C, 2D, 2E (but not including HOV signs), 2F, 2G, 2H, 2I.
- Prepare recommendations for MUTCD including formatting the above referenced sections based on usage criteria and applications creating both a printable version

as a searchable (PDF) and electronic version using CAD geometry in vector based drawing formats (DGN and DXF) and including an SGN compatible with all signs as templates for production. The proposed product will attempt to eliminate the need for a Standard Highway Signs book as the formats and designs will be integral to the MUTCD as a complete reference and production tool.

- Prepare artwork and layout for applicable sections of MUTCD in vector drawing, and CAD compatible formats (DGN, DXF, EPS, PDF, and SGN). Standard signs to be prepared at full scale in production ready format to eliminate the need for costly art creation by states and sign manufacturers.

While the Phase II efforts are separate from the Phase I study, they are an integral part of the overall upgrade concept and should be funded and performed as soon as possible.

### **Draft Final and Final Report**

Upon completion of the field studies, a draft final report that summarizes all findings will be generated and provided for review. An Implementation Plan that provides detail on the broader use of the results of this project will be included in the draft final report. A final report will be prepared taking into consideration the comments received on the draft final report.

### **Management Plan and Staffing**

The proposed project will be performed under the direction of the Pennsylvania Transportation Institute in conjunction with the Texas Transportation Institute, and Meeker and Associates of Larchmont, NY. All project activities will be coordinated through PTI. Dr. Martin Pietrucha of PTI will serve as the principal investigator.

The professional staff working on the project is listed below.

#### **Pennsylvania Transportation Institute (PTI); Penn State University**

- Martin Pietrucha
- Philip Garvey

#### **Texas Transportation Institute (TTI); Texas A&M University**

- Susan Chrysler
- Gene Hawkins
- Paul Carlson

#### **Meeker & Associates, Inc. (M&A)**

- Donald Meeker
- Chris O'Hara

**Science Applications International Corporation (SAIC)**

- Bryan Katz

**Terminal Design, Inc. (TDI)**

- James Montalbano

**SignCad Systems, Inc. (Program Advisors on Standards Development)**

- Judd Roby
- Lynn Berg

**Overall Estimated Budget**

The total estimated cost of this project is \$625,000 (for Phase I). Phase II would be performed at a later time if selected by the TCD PFS panel after Phase I is complete.

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