# PRINCIPLES OF DESIGN

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According to the latest approved version of the MdMUTCD, Traffic Control Devices should "promote highway safety and efficiency by providing for the orderly movement of all road users on streets, highways, bikeways, and private roads". TCD's such as signs, signals and pavement markings should only be used where required by MdMUTCD guidelines or the Maryland Vehicle Code, or where engineering study determines that the use of the TCD is necessary. They are used to convey control, guidance, and navigation information, but are not used to confirm the "rules of the road." Excessive and unnecessary use of TCD's reduces their effectiveness and should be avoided.

Effective design of highway signs, pavement markings, traffic signals, and highway lighting requires sound engineering practices and judgment as well as a basic knowledge of human abilities, decision-making processes, consistency in applying TCD's, and construction methodologies. A good TCD plan will incorporate principles of driver expectancy, visibility, and decision sight distance into the development of a comprehensive traffic operation's scheme. By close observance of standards, any given system of traffic control devices (and accepted practices) will have the same, consistent meaning and require the same action on the part of the motorist regardless of where it is encountered.

On the other hand, do not discourage the development of new standards, use of new technologies, or development of new or seemingly radical concepts. Such developments should be approved by the Director prior to application.

## PRIMARY GOAL OF TCD DESIGN

The primary goal is to produce Traffic Control Device Designs which are:

1. **Defendable** because they comply with national and state standards and criteria.
2. **Best suited to the situation** and represent the best possible plan for all road users.
3. **Effective and consistent**, avoiding clutter, maintaining uniformity, and providing positive guidance.
4. **Responsive** to the *intent* of the original design request.
5. **Constructible** within the field condition, utility, and right of way constraints.

## BACKGROUND CONCEPTS

The MdMUTCD identifies five basic requirements that should be met by effective traffic control devices. These are:

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 order to meet these requirements, the MdMUTCD recommends that responsible jurisdictions do the following:

- Design devices to command attention, provide a clear and concise meaning, provide adequate legibility for driver response, and be applied in a uniform manner.
- Place devices within the driver's field of vision, and positioned such that drivers have adequate time to read, comprehend and react. Placement should be in proximity to the corresponding roadway situation to provide a degree of correlation.
- Apply devices to meet traffic requirements at that location.

- Maintain devices to high standards to ensure visibility and legibility. Devices that are no longer needed or applicable should be removed.
- Apply devices uniformly to aid in driver recognition and understanding. This means treating similar situations the same in terms of device design, application and placement.

## Considering Driver, Vehicle, and Roadway

### Driver Needs

The driving task is affected by aspects of human nature and human ability, including visual acuity, perception-reaction times, driver confidence, distractions, familiarity with roadway, and driver expectations. On a continual basis, drivers are processing information regarding traffic flow, vehicle control (speed, direction, etc.), navigation (where am I going and how will I get there?), and information gathered from the signs, markings, signals, and other devices located along the roadway. With many driver distractions such as audible navigation systems and other technologies, information presented to drivers must command attention and be sufficiently legible such that drivers can recognize, read, understand, and formulate an appropriate response.

### Visibility/Legibility

Two aspects of visibility that concern sign and signal designers are: how far can the driver see a sign or signal (distance), and for how long can the driver read the sign or recognize the signal color (time). These are affected by light levels, travel speed, the relative positioning of the sign and the vehicle, "background (visual) clutter" and the condition of the sign or lens. It is important for sign and signal designers to have a basic understanding of the relationships between driver, visibility, and decision-making when selecting TCD locations.

### Driver Expectancy and Human Factors

As described in *A Users' Guide to Positive Guidance* by Federal Highway Administration, Driver Expectancy is "a driver's readiness to respond to situations, events, and information in predictable and successful ways". Simply stated, motorists respond better to situations they expect than to situations they do not expect, and unexpected situations lead to improper responses and driver error.

The Positive Guidance manual gives 10 general principles for presenting information to motorists and minimizing driver expectancy violations. These principles are:

- **Design for Drivers.** Information should be presented and communicated at the driver's level of understanding. Motorists are not familiar with technical jargon and concepts.
- **Accommodate Target Groups**. This may be as simple as using 20/15 Copy on Guide Signs to improve visibility for elderly drivers. Target groups should be identified where appropriate, and their needs should be incorporated into the design.
- **Be Responsive to Task Demands and Driver Attributes**. Highway information should convey the highway's operating conditions, be sensitive to driver motor-sensory skills, and be responsive to the demands placed on drivers.
- **Satisfy All Information Needs**. All information needs relative to the driving task should be satisfied.
- **Maintain Design/Information System Compatibility**. Information displays and designs should look "compatible" with the rest of the roadway environment.
- **Avoid Surprises and Expectancy Violations**. Surprises cause poor driver reactions and performance, and should be either eliminated or given advance warning. Best practices are to provide a

simple implementation of a TCD device that is easy to comprehend and will invoke the desired reaction by the driver.

- **Eliminate Information Error Sources**. This includes missing or obscured information, misplaced traffic control devices, and obsolete/non-standard devices.
- **Avoid Overload and Under Load**. Drivers tend to make mistakes when required to process too much information and when not enough information is given i.e., where time to comprehend a message and the reaction time to make a corrective action are violated.
- **Provide a Steady Pace**. Information should be well spaced, avoiding localized areas of information overload.
- **Use Primacy when Information Competes**. Information should be prioritized, with control information given precedence over navigation.

## Classification of Roadway

The IESNA advises when selecting a roadway classification, the area or roadway should best fit the descriptions contained within this document and not how classified by others.

- **Freeway:** A freeway is a divided roadway with full control of access (no crossings at grade). This definition applies to toll roads as well as non-toll roads. Freeway classification is further subdivided into A and B. Freeway A has greater visual complexity and high volumes. This is common in urban areas and will operate through some of the early evening hours of darkness at or near design capacity. Freeway B represents all other divided roadways with full control of access.
- **Expressway:** An expressway is a divided major roadway for through traffic, with partial control of access and generally with interchanges at major crossroads. This commonly includes parkways as well.
- **Major:** A major roadway is a principle "arterial," "thoroughfare," or "preferential" for through flow of traffic. These roadways connect areas of principal traffic generation and are sometimes subdivided into primary and secondary.
- **Collector:** A collector roadway services between major and local roadways. These are streets used mainly for traffic movements within residential, commercial and industrial areas that give direct service to abutting properties.
- **Local:** A local roadway is direct access to residential, commercial, industrial or other property. They make up a large percentage of the total street system, but carry a small proportion of vehicular traffic.

## Uniformity of Application

The uniform application of traffic control devices on a nationwide or statewide level reinforces driver expectancy and conditions them for what lies down the road. Simplicity of sign messages and consistency of signing, signals and marking schemes reduces comprehension times of motorists. Drivers learn to associate specific traffic control devices with similar types of situations, improving recognition and comprehension times. For this reason, FHWA has developed the *Manual on Uniform Traffic Control Devices (MUTCD)* and Maryland SHA has published the *Maryland Manual on Uniform Traffic Control Devices (MdMUTCD)* and the *Standard Sign Book*. These manuals are the backbone of uniformity, outlining how signs are applied and how to design an effective system. Contact TEDD for the latest adopted version of the MdMUTCD and associated manuals.

## Considering Fabrication and Construction

The fabrication and construction of TCD's will influence their design. In order to effectively design any TCD it must be able to be

fabricated and constructed. This is a key element to consider in the design process. For example, if an overhead structure is planned to be designed and placed on a bridge, it needs to be confirmed that this is physically possible due to structural constraints. Some things to consider during construction are utility locations (to avoid conflict), structural limitations, material availability, and other highway elements such as drainage structures, barriers, slopes, roadway curvature, etc.

### Policies, Directives, Standards, and Guidelines

Maryland SHA has several tools to use for defining the use, application, and installation of traffic control devices. Policies, Directives, Standards, and Guidelines are four documents, which can be used to define how MSHA applies traffic control devices. All are used to guide the design and installation of signs, signals, and sign/highway lighting; however, each provides different information and offers a different degree of flexibility in implementation.

A policy defines MSHA practice for the use and application of traffic control devices. Written policy statements are usually published and distributed for implementation on a statewide level. A policy is a regulation, method or procedure adopted by MSHA from which there is little deviation. For instance, it is MSHA policy to install Accessible Pedestrian Signals (APS) and Countdown Pedestrian Signals (CPS) at all signalized crosswalks. The MdMUTCD is an example document that sets MSHA policy.

A directive is a statement governing the design and installation of traffic control devices for particular situations or for particular devices. Directives are similar to policies and can cover similar information, however they can be implemented as an interim measure prior to final publication of an official policy. Directives are approved by and originate from the Director of the Office of Traffic & Safety.

Standards are used to define specific information regarding traffic control device fabrication, construction drawings, details, or requirements, and typical installation information intended for frequent and repetitive use in the state of Maryland. MSHA standards define foundation sizes for steel supports and show breakaway modifications for both wood and steel sign supports. They also show vertical and lateral sign clearances, extruded aluminum panel dimensions, and standard sign layouts. Standards define a broad range of information, which is used as the basis for designing and constructing all projects. This provides uniformity on a statewide basis while allowing some flexibility on each project. Standards are typically found in the Book of Standards for Highway and Incidental Structures and in the Standard Sign Book. The approvals come from MSHA and FHWA.

Guidelines state a preferred practice or methodology that relates to an interpretation of a policy or standard, which should be applied where possible and practical. They are not absolute statements and require a great deal of Engineering Judgment in the design process. The Director of the Office of Traffic & Safety approves guidelines. An example guideline covers the application of message dividers on guide signs.

## WORDS OF WISDOM

In the spring of 1997, former Director Hicks wrote an article in The Traffic Peek, offering advice for traffic engineers. The following advice is taken from that article.

Take theory, the laws of physics, and basic human behavior knowledge:

- Apply them to the real world.
- Remember that safety is our #1 goal.

- Recognize the value of consistency and uniformity, and provide them.
- Do not be afraid to innovate, but follow the guiding principles.
- Understand and fulfill an acceptable standard of care.
- Teach the principles and explain them through Public Relations and Public Involvement & Education programs.
- Recognize the speed-distance relationships and apply them.
- Remember the Malfetti graph.
- Follow the fundamental principles of traffic control.
- Consider and respond thoughtfully to the politics of the situation.
- Address the problem and meet the needs of the road users – motorists and pedestrians; be responsible.
- Develop alternatives for every situation.
- Recognize the basic human factors and the capabilities of the driver and pedestrian.
- Recognize that man can think about only one task at a time.

Some thoughts on Human Factors:

- Drivers respond first to stimuli, the whole scene of what they see, comparing that with what they have learned through experience.
- The driver comparison of what they see with their stored knowledge is instinctive and super-fast, in split seconds; this is where following standards and consistency and uniformity come into play.
- Drivers drive on “automatic-pilot” in a semi-conscious state with regard to the driving task; a second reason for consistency and uniformity in applying traffic regulations, control devices, and geometrics.
- Drivers should be confronted with what they expect to find:
    - First corollary: drivers finding what they expect are prepared and greater safety and comfort is the result.
    - Second corollary: drivers not finding what they expect experience discomfort, make poor or wrong decisions, get lost, have crashes, run red lights, or otherwise experience or do the things that discredit our road system and cause it to fail.
- Drivers should be provided with control devices, delineation, geometrics, and highway design features that provide positive direction and controls that reassure and give a high degree of confidence and a feeling of well-being.
- Travel paths should be responsive to how the drivers wish to travel, not the reverse.
    - Corollary: fit the road to the driver, not the reverse.

A good rule to follow – Louis J. Pignataro in his traffic engineering text *Traffic Engineering Theory and Practice*, 1973 says ”A good general guide to the application of control devices is to utilize the minimum degree and control necessary to provide safe and efficient movement of vehicles and pedestrians”.