A New Functional Classification for Improved Multimodal Designs

Nikiforos Stamatiadis and Adam Kirk

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A New Functional Classification System for Improved Multimodal Designs

Nikiforos Stamatiadis[1][0000-0003-3842-2682] and Adam Kirk[2]

[1] Department of civil Engineering, University of Kentucky, Lexington KY 40506-0281, USA
[2] Kentucky Transportation Center, University of Kentucky, Lexington KY 40506-0218 USA
nick.stamatiadis@uky.edu; adam.kirk@uky.edu

Abstract. The Functional Classification System (FCS) that is in use in the USA and serval countries throughout the world was developed in the 1970s as a basis for communication between designers and planners to establish a common framework for classifying roadways based on mobility and access. Since its inception, the application of the FCS has expanded, and is now used throughout the entire project development process and influences all transportation project development phases, from programming and planning through design and into maintenance and operation decisions. However, the binary contextual definitions (urban and rural), do not provide the dynamic range of design elements and guidance needed to balance other competing project needs. A flexible framework that replaces the FCS and facilitates optimal geometric design solutions that take into account context, functions, and user needs has been developed. The Expanded FCS communicates improved information to the designer so that balanced designs can be achieved through documented prioritization of roadway users. The proposed classification identifies user groups, which include drivers, pedestrians, and bicyclists. Fundamental design elements for each mode are also identified, and design ranges for each are provided based on the overall roadway network type. The correlation results of context, roadway types, and users is displayed in the Expanded FCS matrix. This allows for the development of a multimodal, context-based design with some degree of flexibility. Each matrix cell defines the various users (drivers, bicyclists, and pedestrians) and identifies those characteristics to be balanced.

Keywords: Functional Classification System, Multimodal Design.

1 Introduction

The Functional Classification System (FCS) as contained in *Policy for Geometric Design of Highways and Streets*, or Green Book [1] was developed in the 1970s as a basis for communication between designers and planners [2]. The system sought to establish a common framework for classifying roadways based on automobile centric mobility and access. Since its inception, the application of the FCS has expanded. It is now used throughout the entire project development process, influencing all work phases, from programming and planning through design and into maintenance and operation decisions. Within design functions in particular, the FCS is often used to define the range of permissive or desired design elements, such as lane width, shoulder width or design speed. The limited range of functional classes, in addition to the severely limited contextual categories (urban and rural), often yields unresponsive designs focused solely on auto-centric travel. Standards based on the FCS often severely limit design choices when developing a transportation solution intended to: 1) meet the purpose and needs of today's multimodal transportation projects, and 2) be adapted to the context in which they are expected to be successful. The FCS has been very useful in the past when the focus was on the automobile and the system was being addressed from a more regional system perspective.

In recent years, a significant emphasis has been placed on the development and expansion of flexibility in highway design to address competing project needs. Flexible design has been the primary goal of Context Sensitive Design/Context Sensitive Solutions (CSS), Practical Solutions, and Performance Based Practical Design (PBPD) initiatives have been adopted by many state Departments of Transportation (DOTs) in recent years. CSS and PBPD approaches attempt to find "right-sized" transportation solution for roadway users; the goal is for the solution to fit within the roadway environment. These approaches examine varying design elements needed to balance the unique requirements of the project, including the multimodal needs to be incorporated. The narrow focus of the FCS, which considers only automobile-centric mobility and access, as well as its limited and sometimes vague contextual definitions (urban and rural), does not provide the dynamic range of design elements and guidance needed to balance other competing needs. While there is a range of design values available, practically speaking, the existing FCS does not consider other users nor set priorities for the adjustment of the geometric design in order to achieve an innovative or successful project taking into account context, user needs, and function.

NCHRP Project 15-52 developed a flexible framework to replace the FCS aiming to facilitate optimal geometric design solutions that address context, user needs, and functions though a multimodal approach [3]. The proposed classification system communicates improved information to the designer so that multimodal balanced designs can be achieved through consideration and prioritization of roadway users while considering the project context.

2 Expanded Functional Classification System

A thorough review of existing alternative classification systems was the first step in the efforts to develop the replacement of the current FCS. This was coupled with a survey of state agencies and practitioners to define how the current FCS is utilized throughout the project development process. The research team completed a detailed review of 17 existing functional classification systems to determine elements that could be useful in establishing a range of options and in defining a new classification system. All systems have an expanded context definition, ranging from four to 11, and most have defined road functions that expand on the traditional three-tier approach of the arterial-collector-local system. The majority of these systems developed a matrix that correlates context and road types that in turn is tied to design elements (i.e., tables with values or design considerations, elements to be considered, and their range of values). For some systems, there is a third dimension in the classification where modal priorities or other factors such as jurisdiction and environmental aspects are considered. This is achieved by either the explicit inclusion for specific roadway types or through consideration within the design elements as modal priorities.

Through the use of an advisory panel, alternatives and survey results were evaluated to identify the desired components of the new FCS. It was universally agreed that the roadway context needs to be expanded and multimodal user needs need to be emphasized. The resulting proposed functional classification (referred here as the Expanded FCS) expands the context categories to five including Rural Town, Suburban and Urban Core beyond the traditional Urban and Rural contexts. These contexts are defined based on density (existence of structures and structure types), land uses (primarily residential, commercial, industrial, and/or agricultural), and building setbacks (distance of structures to adjacent roadways).

Roadway type definition in the Expanded FCS have changed and are based on their network function and the connectivity they provide among various centers of activity instead of simply automobile-centric mobility and access definitions. In this case, the network function considers the regional and local importance of the roadway as it pertains to vehicle movement while the connectivity recognizes the types of activity centers and locales that are connected with the particular roadway. The existing roadway names were retained to allow for an easier application and adoption of the Expanded FCS.

Ito address multimodal considerations, classifications for bicycles are also proposed to confer structure and priority for bicycle networks extending the automobile-based roadway type definitions. The proposed facilities are categorized based on the network connectivity a facility provides. However, the network scale is modified to reflect the nature of shorter bicycle travel ranges. The proposed classifications are:

- *Citywide/Regional Connector (CC)*—providing citywide/regional connections, connections to major activity centers, or regional bike routes that stretch over several miles and attract a high volume of use as they serve a primary commute or recreational purpose.
- *Neighborhood Connector (NC)*—providing neighborhood or sub-area connection, which establishes connections to higher order facilities or local activity centers such as neighborhood commercial centers.
- *Local Connector (LC)*—providing local connections of short lengths, internal connections to neighborhoods, or to higher order facilities.

Automobiles and bicycles allow for the planning of networks in incorporated areas, but pedestrian activity is typically defined by the immediate context of the area. This is due to the relatively short range and localized typical pedestrian activity that may not extend throughout the entire context area.

The Expanded FCS matrix correlates context, roadway types and users allowing for the development of multimodal, context-based designs with flexibility (Fig.1). Within each matrix cell drivers, bicyclists, and pedestrians are considered and the characteristics to be balanced are identified. The matrix also identifies fundamental design accommodation elements for each mode (e.g. speed, bicycle facility type, sidewalk width), and design ranges for each are provided based on the overall roadway network type.

Context / Roadway	User	Rural	Rural Town	Suburban	Urban	Urban Core
Principal Arterial		H speed H mobility-L access	L/M speed M mobility-H access	M/H speed M mobility-M access	L/M speed M mobility-M access	L speed M mobility-M access
		LC: L separation: NC: M separation: CC: H separation	LC: L separation: NC, CC: M separation	LC: L separation: NC: M separation: CC: H separation	LC: L separation: NC: M/H separation: CC: H separation	LC: L separation: NC, CC: M separation
		P1: *: P2: Min: P3, P4: Wide	P2: Min: P3: Wide : P4:Enhanced	P1: *: P2: Min:P3: Wide: P4: Wide	P2: Min: P3: Wide: P4: Enhanced	P3: Wide: P4:Enhanced
Minor Arterial		H speed H mobility-M access	L/M speed M mobility-H access	M speed M mobility-M access	L/M speed M mobility-M/H access	L speed M mobility-M/H access
		LC: L separation: NC: M separation: CC: H separation	LC: L separation: NC, CC: M separation	LC: L separation: NC: M separation: CC: H separation	LC: L separation: NC, CC: M separation	LC: L separation: NC, CC: M separation
		P1, P2: Min P3, P4: Wide	P2: Min: P3: Wide : P4:Enhanced	P1: *: P2: Min:P3: Wide: P4: Wide	P2: Min: P3: Wide: P4: Enhanced	P3: Wide: P4:Enhanced
Collector		M speed M mobility-M access	L speed M mobility-H access	M speed M mobility-H access	L speed M mobility-H access	L speed M mobility-H access
		LC: L separation: NC, CC: M separation	LC, NC: L separation: CC: M separation	LC: L separation: NC, CC: M separation	LC: L separation: NC, CC: M separation	LC, NC: L separation: CC: M separation
		P1, P2: Min: P3, P4: Wide	P2: Min: P3: Wide : P4:Enhanced	P1: *: P2: Min:P3: Wide: P4: Wide	P2: Min: P3: Wide: P4: Enhanced	P3: Wide: P4:Enhanced
Local		M speed M mobility-M access	L speed M mobility-H access	L speed L mobility-H access	L speed L mobility-H access	L speed L mobility-H access
		LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation:
		P1, P2: Min: P3, P4: Wide	P2: Min: P3: Wide : P4:Enhanced	P1: *: P2: Min:P3: Wide: P4: Wide	P2: Min: P3: Wide: P4: Enhanced	P3: Wide: P4:Enhanced

Speed, Mobility, Accessibility and Separation levels: H: High; M: Medium; L: Low
Bicycle Connectors: LC: Local; NC: Neighborhood; CC: Citywide
Pedestrian traffic levels: P1: rare/occasional; P2: low; P3: medium; P4: high
Pedestrian facility width: *: site specific considerations; Min: minimum; Wide: greater than minimum; Enhanced: wide for large congregating pedestrian groups
Pedestrian facility separation should be considered in conjunction with driver target speeds

Fig. 1. Expanded FCS multimodal matrix by context and roadway type

3 Multimodal Accommodations

The development of multimodal solutions is founded on the identification from the outset of the various user needs and consideration when balancing design element tradeoffs while developing contextually appropriate solutions. The Expanded FCS has developed guidance on accommodations and design considerations for each user group to assist in the balancing their needs and addressing potential conflicts when users share facilities.

3.1 Driver Accommodation

The target operating speed and the balance between mobility and access are the metrics used to define the context-roadway interaction for drivers.

Three categories are used for the target operating speed: Low (<30 mph), Medium (30-45 mph), and High (>45 mph). The concept of medium speed is introduced here, which is absent from the *Policy for Geometric Design of Highways and Streets*, or Green Book [1], while the others coincide in general with current speed definitions in the Green Book. In the Expanded FCS, speed in general decreases along the context continuum (from Rural to Urban Core) as well as along the roadway type (from Principal Arterials to Locals).

These limits are based on established practices and extensive research. For low speed environments, the speed of 25 mph was considered as the limit based on current urban area trends to facilitate a speed limit of 25 mph and on the fact that 20 mph is considered the survivability speed for pedestrians and bicyclists in the event of a collision with a vehicle. The use of target operating speeds of 20 mph or less should be considered in Urban and Urban Core environments of higher pedestrian activity. The designer should select the operating speed most appropriate for all users given the facilities and context within the identified range. The upper limit for high speeds is based on the Green Book definition of high speed roads; those with speeds of over 50 mph.

The Expanded FCS improves the typical tradeoff between access and mobility currently in use reflecting the changes of roadway and context across the various matrix categories. Access is defined now as the frequency of driveways or intersections utilizing three categories based on distance between access points: Low (>0.75 mi), Medium (0.75-0.25 mi), and High (<0.25 mi). Mobility is defined qualitatively as a function congestion level. There are three categories: Low (congested conditions), Medium (some congestion), and High (no congestion; free flow). Current access management concepts and principles aided in the definition of the values for the access. Despite the desirability for access density to decrease on higher mobility roadways, within certain contexts this may not be appropriate since the roadway may also serve as the primary means of access. Mobility levels are based on generalized concepts of the level of service for a facility and correspond to broad values of all roadways.

3.2 Bicyclist Accommodation

The level of separation between motorized and bicycle traffic is the primary design consideration for bicyclists. Other factors that can help determine the proper treatment of bicyclists are discussed as well.

The amount of separation between motorized traffic and the bicycle facilities is based on the volumes of vehicular and bicycle traffic as well as the speed of motorized traffic. In the Expanded FCS, there is: High (physical separation from traffic in the form of physical barrier or lateral buffer), Medium (dedicated space adjacent to motorized traffic), and Low/No separation (shared use facilities for motorized and non-motorized traffic).

It should be noted that the designer has the ability to consider variances in separation implemented. As an example, one may consider a high-speed Urban Principal Arterial serving also as a regional bicycle connection, with heavy bicycle volumes. In this instance, a cycle track or even independent multi-use paths may be appropriate to serve the bicycle traffic, i.e., high separation. The higher separation reduces the number of conflicts between the two modes of traffic, which may be frequent considering the high traffic volumes of both modes. Conversely, at Local Road, which have low speeds, serving only local riders, bicycles and vehicles may share the same space due to the low probability of conflict and low speed differential between the two modes.

Specific treatments to be used for each level of separation are as follows:

- Low/No Separation Treatments
  - No specific treatment, for cases with rare or occasional bicycle traffic.
  - Sharrows — for cases when a bicycle lane is not feasible and they can be used either with narrow lanes, ensuring that a driver can only pass a cyclist very slowly.
- Medium Separation Treatments
  - Bike lanes — for separating bicycles from vehicular traffic.
- High Separation Treatments
  - Buffered bike lane/cycle track — for cases with high bicycle volume.
  - Multi-use path — for cases with high bicycle and pedestrian traffic.

3.3 Pedestrian Accommodation

The width of the facility used for the pedestrian accommodation is the primary design consideration of the Expanded FCS. Additional factors that can be used to help determine the appropriate treatment for pedestrians are discussed as well.

The width of the facility is used to categorize them and four categories are used in the Expanded FCS: * (require site specific consideration), Minimum (minimum required width based on American with Disabilities Act (ADA) requirements), Wide (wider than minimally required width for a pedestrian facility), and Enhanced (additional space than the wider width to accommodate congregating groups of pedestrians, street furniture and landscaping).

Separation of the pedestrian facility from the travel way is also an important consideration, but this mainly depends on the vehicular speed rather than on the level of pedestrian activity. Some separation is typically desirable for medium and high speed facilities that can be as simple as a bicycle lane or parking area. In general, no separation is needed for low speed facilities.

4 Application

The Expanded FCS can be used during the design phase to understand the role the roadway will play in both the context within which it will be constructed and the role it plays within the network. The Expanded FCS provides for the identification of the user groups that must be accommodated within the roadway and assists in prioritizing and balancing their needs while considering how the project fits within the individual network of each road user. A concept that needs to be clarified from the outset is that accommodating all the users at all times on all roadways is impossible.

The needs of the various user groups will often compete and sometimes they may result in conflicts. In these situations, a more global approach is needed to address them where parallel routes should be sought within the network to meet the transportation needs of any of the conflicted user groups. For example, while it may be desirable to accommodate a significant volume of bicyclists on an arterial that may require high separation, heavy vehicle volumes may present a challenging tradeoff decision and in this case, parallel roads can be used to divert the bicycle traffic and establish the required separation. The notion to be emphasized here is that all users must be accommodated within the transportation system, but not all have to be always on the same road. In other words, all users should be fully supported by the total network. Therefore, designers should not only identify and understand the needs of all users, but they also need to understand the priority of users within the route and their modal networks. The traffic generators for each mode need to be identified in order to allow for providing the required connections between points of attraction. In this case, the design should accommodate intended users either on the road of concern or on a parallel route.

Each cell in the Expanded FCS provides designers with a range of design options based on the defined context and roadway combination. Designers have already identified the priorities among the various users and they utilize a CSS process to further refine these design options and balance project needs and community values. At this stage, the needs of the driver, bicyclist, and pedestrian as they relate to the project should be determined and potential accommodations based on the concepts defined from the matrix cell ranges should be developed. Finally, transit or freight overlays should be considered at this point as well. This will result in the determination of the individual user needs and identification for potential design tradeoffs required to best accommodate all users. Alternative designs should be developed and evaluated in order to deliver a context-appropriate design. Designers need to pay special attention when speeds transition from high to low and when considering context with changes to modal accommodations. Future changes based on community vision plans should also be considered to determine their potential impacts on the design developed.

The final step in this process is the development of the cross section and a final determination of how the users are best accommodated within the available right-of-way. The use of available tools, such as the Highway Capacity Manual [4], Highway Safety Manual [5] and simulation, for evaluating different options is highly recommended to determine the advantages and disadvantages of each alternative. PBPD concepts and principles can be implemented to evaluate safety and operational performance of alternatives. Central to this process, is the development of performance metrics that would allow for an objective evaluation of the alternatives and direct comparison to the purpose and need goals and specific objectives.

5 Conclusions

The application of the existing FCS has permeated throughout the project development process. An issue of concern regarding the impacts of the existing FCS on design has been its linkage to geometric design standards. State transportation agencies now depend on defined design guidelines as design standards as a means of avoiding agency liability because of the status given to the AASHTO Green Book and state design manuals. With these standards often closely linked to functional classification, it has fostered a degree of inflexibility in roadway design—especially in urban streets—that limits an agency's inclination to explore flexible designs for a project that are necessitated by CSS and PBPD.

The Expanded FCS addresses this issues through the consideration of the needs and accommodation of user groups; drivers, pedestrians, and bicyclists. For each mode, design options are identified and primary metrics of accommodation are considered based on the overall roadway network type. The proposed process requires that the various user needs are identified from the outset and considered when tradeoffs are needed in order to develop contextually appropriate multimodal solutions. The Expanded FCS matrix synthesizes context, roadway types, and users and allows for the development of a multimodal, context-based design with some degree of flexibility.

The Expanded FCS requires an understanding of the roadway role and place within each modal network and uses it to address competing user needs. This allows for balancing modal needs and developing a more complete, network-wide transportation solution that would address all needs. This balancing may require consideration of solutions where users may be placed on alternative routes that they may be more compatible with the specific user needs. On high-speed Principal Arterials, for example, bicycles and pedestrians may need to be accommodated on a parallel roadway with lower speeds. Likewise, a Principal Arterial with high bicycle demand and mobility needs may require the presence of bicycle facilities that would possibly reduce the number of available vehicle lanes if there is limited right-of-way or reduce speeds.

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