

Street Connectivity

What Is Street Connectivity?

Connectivity involves a system of streets providing multiple routes and connections to the same origins and destinations. Connectivity relates to how an entire area is connected by the street system, not only to the number of intersections along a street segment.

A highly connected area includes a system of parallel routes and cross connections, few closed-end streets, many points of access, and narrow streets with sidewalks or off-street paths. Frequent intersections are provided which create a pedestrian scale block pattern. Traffic calming devices can reduce speed.¹

By contrast, a cul-de-sac street pattern, typical of recent subdivision design in the OKI Region, typically has very long blocks and many dead end streets. This pattern offers few route options since all traffic is funneled out onto a small number of arterial roads, which can cause congestion. In addition, arterial roadways typically are designed to handle only motor vehicle traffic, and are not accommodating to pedestrian and bicycle traffic. A pattern of streets with numerous connections and short blocks makes it easier to move around.

Why Is Connectivity Important?

Increased connectivity can...

- ...decrease traffic on arterial streets.
- ...reduce travel time.
- ...create shorter travel distances & reduce the number of vehicle miles traveled.
- ...provide continuous and more direct routes for travel by walking and biking.
- ...provide greater emergency vehicle access and reduced response time.
- ...provide improved utility connections, easier maintenance, and more efficient trash and recycling pick up.
- ...lower speeds and reduce accident severity.
- ...better accommodate transit use.

How Can Connectivity Standards Be Implemented Effectively?

Language relating to connectivity in the comprehensive plan is essential for providing a basis for related regulation. An evaluation of the community's future land uses and the streets required to support new development is the first step in identifying the steps necessary to achieve desired results. Comprehensive plans can assist in identifying critical future street connections and areas where improvements need to be made to serve existing communities. Many communities find it beneficial to create future street plan maps within the local comprehensive plan.

To effectively implement connectivity standards, some communities choose to study the traffic impacts of increasing the number of local street connections. Results of such a study would provide a proper range of the number of street connections per mile that will give the greatest benefit. Study results may also show how much traffic delay would be reduced.

¹ Transportation and Growth Management, Oregon Department of Transportation, "Connecting Transportation & Land Use Planning: Street Connectivity", 2003, http://darkwing.uoregon.edu/~cpw/projects/pdf/featured/tgm_2003/educational%20materials/Street%20Connectivity_Brief.pdf, (accessed July 5, 2006).

Typical standards for connectivity create connections to existing or planned street intersections and extensions, provide direct and logical access to surrounding areas, and limit the number of cul-de-sacs and closed end streets. The spacing of access points between full street connections is also limited, except where prevented by barriers. Closed end streets also have a length limit or a limit on the number of dwelling units that can be served by that street.

When street connections are not possible because of physical constraints such as topography, provisions for bicycle and pedestrian access on public easements are suggested. Short public right-of-way routes that can connect residential neighborhoods with neighborhood services, schools, parks and other neighborhood facilities can also encourage pedestrian travel. The street systems in well-connected neighborhoods serve a mix of development types with continuous street patterns. In addition, narrow street design alternatives should be a consideration. In areas that are already developed without street connections, extending and connecting streets from nearby areas incrementally may be appropriate.

Connectivity Challenges

Resistance to increased connectivity may come from citizens and from developers. Residents of established areas may be concerned about the potential for increased traffic and may also oppose increasing connections to their communities by extending existing street stubs or cul-de-sacs. Changes in traffic distribution may make residents concerned about safety and privacy. In areas adjacent to undeveloped property, street stubs for future new development may generate concern that the adjacent property will develop, or how it will develop.

Developers may resist meeting new requirements and potential decreases in the amount of salable land they will have for their development. With increased connectivity, some potential building lots may be lost to transportation connections. Depending on the size of the project, a developer may argue that this will increase costs and reduced profitability of the development.

There may also be increased initial infrastructure costs because the overall amount of impervious cover may be greater. Permitting narrower streets can be a partial solution to this challenge. Increased connectivity benefits services in terms of ready access but emergency responders may be concerned about navigating narrower streets.

There will also be challenges for planning and engineering staff to balance the reduction of traffic on arterial streets with increased traffic on residential streets. Proper study and evaluation of the needs and characteristics of the community are necessary.

Model Regulations

Included in this model are variations of evaluating whether connectivity is appropriate in proposed developments. The following examples are presented as a starting point for considering zoning provisions that encourage connectivity in certain situations. The communities represented have selected certain requirements, such as a connectivity index (that some communities choose to require), length of cul-de-sacs, and maximum block lengths that should match the characteristics of different neighborhoods. The included text is only a portion of a much larger ordinance that can be consulted for additional information. The appropriate local planning and legal staff should craft any new zoning language proposed to be adopted within a community to reflect local priorities and implement local goals and objectives.

Purpose Statement

An explicit statement of purpose and intent helps to clarify the legal and policy basis of site and design standards for connectivity if they are later challenged in court. These statements connect the intent language that may be included in a community's comprehensive plan to specific language within regulations. They also provide direction for interpretation and discretionary decisions. These purpose statements should be tailored to support the community's vision and its objectives for connectivity.

Problem Statement: The zoning ordinance often provides general language regarding the provision of street connections within new development and to existing development. Often, however, it is unclear how street patterns affect congestion, land use patterns, air quality, and overall quality of life. For that reason the overall intent of the regulations is sometimes not met.

Objective: To clarify that one purpose of the zoning ordinance is to support a connective transportation system that is designed for safety, efficiency, and convenience for multiple modes of travel.

Code Writing Strategy: Include a purpose statement in the zoning ordinance or subdivision regulations that clearly encourages or requires connectivity and, if applicable, that relates it to a specific plan for implementation.

Purpose Statement - Sample Code Language:

Land Development Ordinance, Town of Cary, North Carolina

7.10.1 Purpose and Scope

The purpose of this section is to support the creation of a highly connected transportation system within the Town in order to provide choices for drivers, bicyclists, and pedestrians; promote walking and bicycling; connect neighborhoods to each other and to local destinations such as schools, parks, and shopping centers; reduce vehicle miles of travel and travel times; improve air quality; reduce emergency response times; increase effectiveness of municipal service delivery; and free up arterial capacity to better serve regional long distance travel needs. Any additional pedestrian connections required under this Section do not have to address handicap accessibility standards.

Land Use Code, Fort Collins, Colorado

Article 3: General Development Standards

Division 3.6 Transportation and Circulation:

3.6.3 Street Pattern and Connectivity Standards

(A) *Purpose.* This Section is intended to ensure that the local street system is well designed with regard to safety, efficiency and convenience for automobile, bicycle, pedestrian and transit modes of travel.

Title 33, Planning and Zoning, City of Portland, Oregon

Chapter 33.654 Rights-of-way

33.654.110 Connectivity and Location of Rights-of-Way

A. Purpose. The regulations of this section ensure provision of efficient access to as many lots as possible, and enhance direct movement by pedestrians, bicycles, and motor vehicles between destinations. Direct routes for bicycles and pedestrians from residential areas to neighborhood facilities, such as schools and parks, are particularly important to increase the convenience of traveling by foot or bicycle. The specific location of rights-of-way is influenced by a variety of conditions, including existing development, streets and lot patterns, and environmental features.

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Section 4.8 Four Model Ordinances to Help Create Physically Active Communities:

4.8.4. Model Street Connectivity Standards Ordinance

101. Purpose

(1) The purpose of this ordinance is to support the creation of a highly connected transportation system within the [municipality name] to:

- (a) provide choices for drivers, bicyclists, and pedestrians;
- (b) promote walking and bicycling;
- (c) connect neighborhoods to each other and to destinations, such as schools, parks, shopping, libraries, and post offices, among others;
- (d) provide opportunities for residents to increase their level of physical activity each day by creating walkable neighborhoods with adequate connections to destinations;
- (e) reduce vehicle miles traveled and travel time to improve air quality and mitigate the effects of auto emissions on the health of residents;
- (f) reduce emergency response times;
- (g) increase effectiveness of municipal service delivery; and
- (h) restore arterial street capacity to better service regional long-distance travel needs.

Discussion:

The purpose statement should be tailored to support the community's particular characteristics and reflect goals and objectives that may be found within the community's comprehensive plan regarding transportation. The examples above all include similar language relating to multi-modal travel, providing efficient access to properties, ensuring safety, and reducing congestion.

Street Design

Providing general standards for the location of streets and intersections is a typical technique that communities include in their zoning ordinances or subdivision regulations. This section establishes the process for dealing with physical limitations, interconnecting streets, and design techniques that may be used for street patterns, such as street stubs and traffic calming.

Problem Statement: Street design standards do not always take into consideration the characteristics of the areas surrounding the proposed street extension or improvement. For that reason, streets are sometimes built that do not fit in well with the context of community, or don't meet all of the needs of the surrounding neighborhood.

Objective: To clarify that street design is an important element in the creation or separation of neighborhoods. To include certain techniques into the regulation that can increase accessibility, the available choices for multi-modal transportation, and safety, while respecting the physical characteristics of the land.

Code Writing Strategy: Include language in the zoning ordinance or subdivision regulation that clearly depicts how the streets of a community are to be designed with respect to community characteristics, and physical, accessibility and safety considerations.

Street Design - Sample Code Language

Unified Development Ordinance, City of Knightdale, North Carolina

Chapter 9: Circulation and Connectivity

9.4 Vehicular Connectivity

A. Street Arrangement

Streets should be designed and located so that they relate to the topography, preserve natural features such as streams and tree growth and provide for adequate public safety and convenience. Vehicular connections from adjacent property (street stub-outs) must be utilized unless the Administrator deems the connection impractical due to topographic conditions, environmental constraints, property shape or property accessibility.

Where a through street or a series of streets establishes a connection between two (2) public streets, such street shall be a public street. Local public and private streets may incorporate traffic calming devices. Streets should be designed so pedestrians have convenient and safe means to cross streets. Allowable treatments may include, but are not limited to, roundabouts, raised pedestrian cross walks, multi-way stops, bulb-outs, alternative pavement treatments, and signals at cross walks when warranted.

Land Use Code, Fort Collins, Colorado
Article 3: General Development Standards
Division 3.6 Transportation and Circulation

3.6.3 Street Pattern and Connectivity Standards

General Standard. The local street system of any proposed development shall be designed to be safe, efficient, convenient and attractive, considering use by all modes of transportation that will use the system, (including, without limitation, cars, trucks, buses, bicycles, pedestrians and emergency vehicles). The local street system shall provide multiple direct connections to and between local destinations such as parks, schools and shopping. Local streets must provide for both intra- and inter-neighborhood connections to knit developments together, rather than forming barriers between them. The street configuration within each parcel must contribute to the street system of the neighborhood.

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Section 4.8 Four Model Ordinances to Help Create Physically Active Communities:

4.8.4. Model Street Connectivity Standards Ordinance

104. General Standards

(1) A proposed development shall provide multiple direct connections in its local street system to and between local destinations, such as parks, schools, and shopping, without requiring the use of arterial streets. Each development shall incorporate and continue all collector or local streets stubbed to the boundary of the development plan by previously approved but unbuilt development or existing development.

Discussion:

This section may be used as introduction to additional language regarding street design. Characteristics within communities will differ, especially relating to topography or other natural barriers, and may necessitate a waiver process for the requirement of street extensions.

Block Length

Establishing a maximum block length is one way to evaluate connectivity in proposed developments. The notion here is that grid patterns with shorter blocks, instead of long dead end streets or cul-de-sacs, make it easier to get from place to place within a community, and provide several alternative routes. This concept can assist in reducing traffic congestion as well as increasing options for pedestrian activity.

Problem Statement: Many ordinances include minimum distances between curb cuts for the purpose of minimizing delay for through traffic. While these requirements are sometimes necessary, if not carefully monitored, this can create fewer route options available to motorists, pedestrians and bicyclers. When all of the traffic funnels out onto relatively few roadways, congestion occurs. In addition, the fewer the number of route options, the wider those streets must be to accommodate traffic, which can also reduce pedestrian and bicycle activity.

Objective: To increase the number of route options by reducing block lengths.

Code Writing Strategy: Include language in the zoning ordinance or subdivision regulation that clearly defines the community's standard for maximum block length.

Block Length - Sample Code Language

Unified Development Ordinance, City of Knightdale, North Carolina
Chapter 9: Circulation and Connectivity

9.4 Vehicular Connectivity

B. Block Length

Maximum block lengths inside proposed developments should be in accordance with lengths shown in the following table. Short block lengths are strongly encouraged in order to create a better pedestrian-scaled environment. The Administrator may waive this requirement if it is determined that this requirement is impractical due to topographic conditions, environmental constraints, property shape or property accessibility.

Block widths within neighborhoods should be sufficient to allow two tiers of lots except where single tiers of lots will facilitate nonresidential development and the separation of residential and nonresidential developments or the separation of residential developments from arterials, railroad rights-of-way, linear greenways or parks.

	OSP	RR	GR-3 GR-8	UR-12 RMX	NMX	TC	HB MI
Block Length (Maximum)	n/a	1500 ft	1000 ft	800 ft	660 ft	660 ft	n/a

(Zoning designations refer to the following: Open Space Preserve (OSP), Rural Residential (RR1), General Residential (GR3 and GR8), Urban Residential (UR12), Residential Mixed-Use (RMX), Neighborhood Mixed-Use (NMX), Town Center (TC), Highway Business (HB), Manufacturing and Industrial (MI))

Title 33, Planning and Zoning, City of Portland, Oregon
Chapter 33.654 Rights-of-way

33.654.110 Connectivity and Location of Rights-of-Way

B. Approval criteria.

1. Through streets and pedestrian connections in OS, R, C, and E Zones. In OS, R, C, and E zones, through streets and pedestrian connections are required where appropriate and practicable, taking the following into consideration:
 - a. Through streets should generally be provided no more than 530 feet apart and pedestrian connections should generally be provided no more than 330 feet apart. Through street and pedestrian connections should generally be at least 200 feet apart;
 - b. Where the street pattern in the area immediately surrounding the site meets the spacing of subparagraph a., above, the existing street pattern should be extended onto the site;
 - c. Characteristics of the site, adjacent sites, and vicinity, such as:
 - (1) Terrain;
 - (2) Whether adjacent sites may be further divided;
 - (3) The location of existing streets and pedestrian connections;
 - (4) Whether narrow frontages will constrain creation of a through street or pedestrian connection;
 - (5) Whether environmental overlay zones interrupt the expected path of a through street or pedestrian connection; and
 - (6) Whether existing dwelling units on- or off-site obstruct the expected path of a through street or pedestrian connection. Alternative locations or designs of rights-of-way should be considered that avoid existing dwelling units. However, provision of through streets or pedestrian connections should take precedence over protection of existing dwelling units where the surrounding transportation system will be significantly affected if a new through street or pedestrian connection is not created;
 - d. Master street plans for the area identified in Goal 11B of the Comprehensive Plan;
 - e. Pedestrian connections should take the most direct route practicable. Users should be able to see the ending of the connection from the entrance point, if possible.

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Section 4.8 Four Model Ordinances to Help Create Physically Active Communities:

4.8.4. Model Street Connectivity Standards Ordinance

104. General Standards

- (2) To ensure future street connections to adjacent developable parcels, a proposed development shall provide a local street connection spaced at intervals not to exceed [660] feet along each boundary that abuts potentially developable or redevelopable land.
- (3) A proposed development shall provide a potentially signalized, full-movement intersection of a collector or a local street with arterial street at an interval of at least every 1,320 feet or one-quarter mile along arterial streets. A proposed development shall provide an additional nonsignalized, potentially limited movement, intersection of a collector or local street with an arterial street at an interval not to exceed 660 feet between the full movement collector and the local street intersection.

Land Use Code, Fort Collins, Colorado

Article 3: General Development Standards

Division 3.6 Transportation and Circulation

3.6.3 Street Pattern and Connectivity Standards

- (C) *Spacing of Full Movement Collector and Local Street Intersections With Arterial Streets.* Potentially signalized, full-movement intersections of collector or local streets with arterial streets shall be provided at least every one thousand three hundred twenty (1320) feet or one-quarter ($\frac{1}{4}$) mile along arterial streets, unless rendered infeasible due to unusual topographic features, existing development or a natural area or feature.
- (D) *Spacing of Limited Movement Collector or Local Street Intersections With Arterial Streets.* Additional nonsignalized, potentially limited movement, collector or local street intersections with arterial streets shall be spaced at intervals not to exceed six hundred sixty (660) feet between full movement collector or local street intersections, unless rendered infeasible due to unusual topographic features, existing development or a natural area or feature.

The City Engineer may require any limited movement collector or local street intersections to include an access control median or other acceptable access control device. The City Engineer may also allow limited movement intersection to be initially

Discussion: The appropriate block length for a community should be locally determined based on the scale and character that is desired to be achieved. Maximum block length requirements may need to be longer or shorter if a community is trying to create a town center type development versus cul-de-sac developments and strip commercial developments. The increased connectivity that can be accomplished through this technique can also increase emergency vehicle access and transit access.

Connectivity Index

Connectivity involves a system of streets with multiple routes and connections serving the same origins and destinations. Connectivity relates not only to the number of intersections along a segment of a street but also how an entire area is connected by the street system. The purpose of a connectivity index is similar to the concept of maximum block length. The connectivity index is calculated by the number of street links divided by the number of nodes or link ends (including cul-de-sac heads). The more links relative to nodes, the more connectivity.

Problem Statement: Ordinances typically utilize hierarchical street pattern techniques that provide for higher volumes of traffic and higher speeds on fewer roadways. Increased connectivity is an alternate approach that provides for additional routing options and can therefore also affect congestion. When all of the traffic funnels out onto relatively few roadways, congestion occurs. The fewer number of route options, the wider those streets must be to accommodate traffic, which can also reduce pedestrian and bicycle activity.

Objective: To determine the appropriate ratio of intersections to road segments that will accommodate traffic and increase the number of route options.

Code Writing Strategy: Include language in the zoning ordinance or subdivision regulation that clearly identifies the desired connectivity index and the process for calculating the index.

Connectivity Index - Sample Code Language

Unified Development Ordinance, City of Knightdale, North Carolina

Chapter 9: Circulation and Connectivity

9.4 Vehicular Connectivity

C. Connectivity Index

A Connectivity Index should be used to determine the adequacy of street layout design. This is calculated as the ratio of the number of street links (road sections between intersections) in the project's street layout divided by the number of street nodes (intersections and cul-de-sac heads). For comparison purposes, a perfect grid has a Connectivity Index of 2.0 or higher. The figure for a conventional cul-de-sac subdivision is often 1.0 or less.

The accompanying illustration exhibits a connectivity index of 1.2 (links are shown as circles and nodes are shown as stars). The illustration has 11 links and 9 nodes for an index of $11 / 9 = 1.2$. Any development shall be required to achieve a connectivity index as shown in the following table. The Administrator may award connectivity index reductions if it is determined that more than 60 percent of any “side” of a development (4 sides total) faces impracticalities for connectivity to adjacent properties due to the presence of controlled-access highways, railroad rights-of-way, Neuse River stream buffers or existing developments that have not provided street stub-outs for connection purposes. In addition, the Administrator may award connectivity index bonuses where pedestrian greenways are provided to link any cul-de-sac to another street or cul-de-sac within the development. Street links on existing adjacent streets that are not part of the proposed subdivision are not included in the connectivity index calculation.



	OSP	RR	GR-3 GR-8	UR-12 RMX	NMX	TC	HB MI
Connectivity Index <i>(Minimum)</i>	n/a	1.3	1.4	1.4	1.5	1.6	n/a

Administrator-Awarded Index Reductions	Reduction Value	Administrator-Awarded Index Bonuses	Bonus Value
Controlled-Access Highway, Railroad Right-of-Way or Adjacent Developments with No Street Stub-Outs	- 0.05	Pedestrian Greenway (A minimum of a 20' easement with a 6' path)	+ 0.025
Neuse River Stream Buffer	- 0.025	n/a	n/a

Southeast Orlando Sector Plan Illustrated Guidebook, Orlando, Florida
Circulation Guidelines and Standards

Connectivity Index

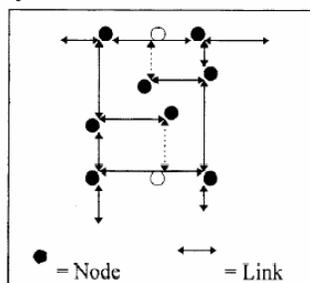
Accessibility and connectivity are complementary concepts. In accordance with GMP [Growth Management Plan] Future Land Use Policy 4.2.5, and consistent with the GMP Transportation Element, the City shall combine the mobility of the traditional interconnected street pattern with the safety, security, and topographic sensitivity of the conventional or contemporary network. Such a hybrid network features short, curved stretches that follow the lay of the land or contribute to good urban design, as well as short loops and cul-de-sacs, so long as the higher-order street network is left intact.

“Higher-order” means arterials, collectors, and sub-collectors that carry through traffic. An acceptable individual project master plan may feature interrupted grids of short streets ending at T or Y intersections, traffic circles or squares/parks. By design, local streets may carry some through-traffic, but the truncated nature of local streets means that traffic moves more slowly and the heaviest volumes are diverted to higher-order streets.

A simple measure of connectivity is the number of street links divided by the number of nodes or link ends (including cul-de-sac heads). The more links relative to nodes, the more connectivity. A connectivity index of 1.4 to 1.8 represents an acceptable street network in the Southeast Plan area. The optimal connectivity index for a perfect grid network is 2.5. This is the procedure for calculating the connectivity index:

1. Count the number of nodes. Nodes are any point of intersection of two or more roads or any cul-de-sac ends. There are 8 nodes in the example (counting only the black nodes).
2. Count the number of links. Links are the segments of road connecting nodes. To properly calculate the connectivity index, you must include the first link beyond the last nodes. There are 12 links in the example (ignoring the dashed lines).
3. Use the following formula to calculate the connectivity index: $links / nodes = connectivity\ index$. The connectivity index of the example is $12 / 8 = 1.5$.

This connectivity index can be improved by removing the cul-de-sacs and connecting the street-ends to other streets (follow the dashed lines). There are still 8 nodes (counting the clear circles and ignoring the black cul-de-sac circles), but there are now 14 links. The index is now 1.8. Simple changes in design can bring about significant changes in connectivity index scoring. The City shall utilize the connectivity index mechanism, in addition to other qualitative measures, to determine whether transportation impact fees can be reduced within the Southeast Plan area.



Discussion:

The acceptable connectivity indexes for developments may differ based on locally determined priorities. The minimum connectivity index may also differ based on the type of land use or the zone in which a project is located. Connectivity indexes should be used in conjunction with other locally determined needs for transportation access.

Cul-de-Sacs

Cul-de-sac street patterns typically have very long blocks and many dead ends. The purpose of regulation regarding cul-de-sac is to control the effect that these patterns have on the street system. Cul-de-sacs may be appropriate in some situations where topography is an issue, or special circumstances arise, but a pattern of streets with numerous connections and short blocks can increase mobility.

Problem Statement: Cul-de-sacs are a development pattern that may be desirable for some communities, but they may also cause mobility challenges if their use is not considered as part of the over all street network.

Objective: To define the appropriate use of cul-de-sacs.

Code Writing Strategy: Include language in the zoning ordinance or subdivision regulation that clearly identifies when cul-de-sacs will be permitted and under what conditions. This may include restricting the length of cul-de-sacs, limiting the number of units served, and provide for waivers.

Cul-de-sac Streets - Sample Code Language

Unified Development Ordinance, City of Knightdale, North Carolina

Chapter 9: Circulation and Connectivity

9.4 Vehicular Connectivity

D. Cul-de-sacs

In general, permanent cul-de-sac streets and dead-end streets are discouraged in the design of street network systems, and they should be used only when topography, the presence of natural features, and/or vehicular safety factors make a vehicular connection impractical. Where cul-de-sacs or dead-end streets are unavoidable, developments shall incorporate provisions for future vehicular connections to adjacent, undeveloped properties, and to existing adjacent developments where existing connections are poor. No system of multiple branching cul-de-sacs from a single junction with a connected street network is permitted, unless the Administrator deems it allowable due to environmental constraints.

Any permanent dead-end streets or cul-de-sac shall comply with the length limits shown in the following table, and shall be provided with a turnaround at the closed end of the street as set forth in the Town's Standard Specifications and Details Manual.

	OSP	RR	GR-3 GR-8	UR-12 RMX	NMX	TC	HB MI
Cul-de-Sac Length <i>(Maximum)</i>	n/a	500 ft	300 ft	200 ft	Not Allowed	Not Allowed	n/a

7.10.3 Standards for Streets/On-Site Vehicular Circulation

(B) Street Arrangement

- (1) The proposed public or private street system shall be designed to provide vehicular interconnections to all similar or compatible adjacent uses (existing and future) when such interconnections would facilitate internal and external traffic movements in the area. Such connections shall be provided during the initial phase of the project approximately every 1,250 to 1,500 linear feet for each direction (north, south, east, west) in which the subject property abuts similar or compatible uses. If the common property boundary in any direction is less than 1,250 linear feet, the subject property will be required to provide an interconnection if it is determined by the Planning Director that the interconnection in that direction can best be accomplished through the subject property. When the Planning Director deems a vehicular connection impractical, he/she can increase the length requirement and/or require pedestrian connections. The Planning Director may delay the interconnection if such interconnection requires state approval or will result in significant hardship to the property owner. The intent of this standard is to improve access/egress for Town neighborhoods, provide faster response time for emergency vehicles, and improve the connections between neighborhoods.
- (2) Any development of more than 100 residential units or additions to existing developments such that the total number of units exceeds 100 shall be required to provide vehicular access to at least two public streets unless such provision is deemed impractical by the Planning Director or Town Engineer due to topography, natural features, or the configuration of adjacent developments.
- (3) Where new development is adjacent to vacant land likely to be divided in the future, all streets, bicycle paths, and access ways in the development's proposed street system shall continue through to the boundary lines of the area under the same ownership as the subdivision, as determined by the Planning Director or the Town Engineer, to provide for the orderly subdivision of such adjacent land or the transportation and access needs of the community. In addition, all redevelopment and street improvement projects shall take advantage of opportunities for retrofitting existing streets to provide increased vehicular and pedestrian connectivity.
- (4) In general, permanent cul-de-sacs and dead-end streets are discouraged in the design of street systems, and should only be used when topography, the presence of natural features, and/or vehicular safety factors make a vehicular connection impractical. Where cul-de-sacs or dead-end streets are unavoidable, site and/or subdivision plans shall incorporate provisions for future vehicular connections to adjacent, undeveloped properties, and to existing adjacent development where existing connections are poor.
- (5) Permanent dead-end streets or cul-de-sacs shall comply with the length limits and design standards set forth in the Town's Standard Specifications and Details Manual, and shall be provided with a turnaround at the closed street end.

SECTION 305: Street Design

N) Temporary Dead-End Streets and Street Connections to Adjoining Tracts or Areas – Dead end streets of a temporary nature and street connections with adjoining undeveloped tracts shall be required by the Commission. Reasons for this include the layout of the subdivision, the staging of development, the opportunity for reasonable access alternatives to adjoining tracts, the necessity of providing through connections between collector or arterial streets, to distribute traffic patterns by providing alternative routes, and to provide convenient and efficient access for emergency vehicles, street maintenance, school buses, postal delivery, and other essential services. The street connection with adjoining property shall be constructed upon Final Plat recording of seventy five percent (75%) of the subdivision lots as approved on the Preliminary Plat, or if a contributing street in the subdivision is within 300 feet of the connection to the adjoining property.

The Commission shall consider the following criteria for requiring street connections to adjoining property:

1. The adjoining land must be compatible with the subject development as determined by the current zoning and/or the Future Land Use Map as specified in the current Comprehensive Plan.
2. Street connections to adjoining properties will not be required if significant grading (as determined by the County Engineer or applicable City Engineer) and/or the construction of a bridge would be necessary to make such connections.
3. Future desired transportation patterns as described by the current Comprehensive Plan and special funding projects recommended in the Transportation Plan shall be considered. The Planning Commission may require a subdivision to include or extend a Limited Access Residential Street (Street, Limited Access Residential- A subcollector or collector street with no direct access for individual lots. Such streets are intended to provide direct and safe circulation within and between developing residential areas and the major street network.) in areas that are recommended as Suburban Residential density or greater on the adopted Future Land Use Map without existing or committed through-streets subject to no individual lot access. The Boone County Comprehensive Plan, adopted Transportation Plan or Thoroughfare Plan, and planned street connections between properties shall be considered in determining this requirement. This provision is intended to avoid subdivision streets with direct lot frontage serving as connections between traffic generating development areas and the major street network.
4. Subdivisions required to provide subcollector or collector streets (as described in the street classification table in Article 5) shall be required to provide for connection of such streets to other collector or arterial streets or connection to adjoining lands.
5. The Planning Commission may require the connection of local streets to adjoining tracts or areas in order to prevent the local street from becoming a cul-de-sac street which exceeds the maximum length permitted for a cul-de-sac street.

6. Proposed connections to the existing street system will be consistent with the existing conditions and the design of adjoining streets.
7. All temporary dead-end streets that will continue onto adjoining property or connect with another roadway will have a sign posted at the temporary dead end that informs the public of the planned street connection.
8. All temporary dead-end streets will be terminated with a temporary turn-around. Storm water flow at a temporary dead-end shall be managed in accordance with the requirements stated herein.

Discussion:

Limiting the use of cul-de-sacs may require that street stubs be provided for future land development on adjacent properties. This may cause confusion if property owners are not aware of the potential for future street extension. Using signage or consulting with the developer or real estate agent to ensure communication will help to reduce confusion and resistance.

Cross-Access

Providing cross-access between properties can benefit businesses, add road capacity, and increase transportation efficiency. Depending on local conditions, in order to access adjacent businesses, motorists often must briefly use an adjoining collector or arterial roadway, making sometimes unsafe maneuvers in short distances. Access management techniques, such as providing cross-access drives, connecting parking lots, or providing service roads, can reduce unnecessary trips and increase safety.

Problem Statement: Many zoning ordinances and subdivision regulations permit multiple curb cuts onto roadways in close proximity to each other. Many ordinances do not require developments to provide access to adjacent parcels. This can have a negative impact on roadways, on safety, and on economic development.

Objective: To eliminate unnecessary trips and maintain road capacity by minimizing turning movements on major roadways, providing sufficient access to businesses, and connecting access to adjacent parcels.

Code Writing Strategy: Include language in the zoning ordinance or subdivision regulation that sets minimum distances between driveways, requires shared parking lots or access drives through adjacent properties, and requires shared access for multiple properties.

Sample Code Language – Cross-Access

Land Development Ordinance, Town of Cary, North Carolina
Chapter 7: Development and Design Standards

7.10.3 Standards for Streets/On-Site Vehicular Circulation

(C) Cross-Access

All non-residential development shall be designed to allow for cross-access to adjacent properties to encourage shared parking and shared access points on public or private streets. A minimum distance of 100 feet shall be required between a cross-access way and an intersection or driveway entrance. When cross-access is deemed impractical by the Planning Director on the basis of topography, the presence of natural features, or vehicular safety factors, this requirement may be waived provided that appropriate bicycle and pedestrian connections are provided between adjacent developments or land uses. A cross-access easement must be recorded prior to issuance of a Certificate of Occupancy for the development.

Unified Development Ordinance, City of Knightdale, North Carolina

Chapter 9: Circulation and Connectivity

9.4 Vehicular Connectivity

E. Cross-Access

Traffic studies have shown that highly connected street networks provide much greater traffic throughput and mobility for a community, at less cost. A high degree of connectivity should occur not only at the level of arterials, but also on collector, local and other secondary roads. Such connectivity vastly improves a street network's performance. The street pattern should not force short trips of one (1) or two (2) miles onto arterials; it should be possible to make trips of this sort by using collector or other secondary streets. With a highly connected street network, cross-town trips should be possible using fairly direct secondary roads.

All development in HB and MI zoning districts shall be designed to allow for cross-access to adjacent properties to encourage shared parking and shared access points on public and private streets. When cross-access is deemed impractical by the Administrator on the basis of severe topography, environmental constraints or vehicular safety factors, the requirement may be waived provided that appropriate bicycle and pedestrian connections are provided between adjacent developments or land uses. Development plans should provide cross-access easement and complete the connection if completing the link can derive an immediate benefit. If no immediate benefit can be derived, development plans should provide cross-access and construction easements and arrange the site design so when the adjoining property owner extends the connection to the property line, the link will be completed. If the link is to be completed in the future, the grade of the connection, parking, landscaping, and other improvements must be set to allow for extension into the adjacent property.

2001-2002 Zoning Regulations, Boone County Planning Commission, Kentucky

Article 32: Transportation Management Regulations

Section 3236: Provision of Frontage Roads

The Planning Commission may require the use of frontage roads to provide access to property adjacent to arterial and collector roadways. The landowner/developer may be required to construct the frontage road to the side and/or rear property lines or reserve sufficient right-of-way to allow future construction of such road.

As adjacent property develops, the landowner/developer shall be required to interconnect the individual portions of frontage roads as appropriate. Access to the roadway via an intersecting street or a common driveway may be required if the use of a frontage road is not feasible, as may the interconnecting of parking lots.

Discussion: Businesses may be hesitant about limited access where shared or combined access points are planned, leaving some businesses with only access to major roadways through cross-access easements on parking lots or via frontage roads. Combining access points and providing for cross-access, however, increases the safe accessibility for businesses that may be located on a busy roadway where turning movements are difficult.

Pedestrian and Bicycle Connections

Increased connectivity provides for bicycle and pedestrian activity. In instances where it is difficult or impossible to extend a street, or where the street layout does not encourage multi modal transportation, the use of exclusive pedestrian and bike paths can help to increase connectivity. Increased connectivity can shorten walking trips and reduce vehicular trips. (Also see OKI's *Bicycle and Pedestrian Facility Standards* sample ordinances.)

Problem Statement: Many zoning ordinances require sidewalks and bike paths as part of street design and improvements. There are often instances, however, where cul-de-sac streets exist or are necessary, but create gaps in the pedestrian or cycling network.

Objective: To increase bicycle and pedestrian activity on adequate infrastructure.

Code Writing Strategy: Include language in the zoning ordinance or subdivision regulation that requires or encourages pedestrian or bicycle path connections between long blocks or connecting with the ends of long cul-de-sacs. This includes requiring adequate construction of the infrastructure for safety and convenience.

Land Development Ordinance, Town of Cary, North Carolina

Chapter 7: Development and Design Standards

7.10.4 Standards for Pedestrian Facilities

In addition to the general provisions of Section 7.10.3 above, the following specific standards shall be met in designing and achieving a pedestrian circulation system in new residential and non-residential development:

(A) Sidewalks

(1) All sidewalks shall be designed to comply with the standards provided by the Design Guidelines Manual, the Downtown Design Guidelines, and the Standard Specifications and Details Manuals.

(2) Sidewalks shall be installed on both sides of all arterials, collector streets, and nonresidential cul-de-sacs, and within and along the frontage of all new development or redevelopment. On local streets, sidewalks shall be required on only one side of the street. Loop streets and/or residential cul-de-sacs are not required to have sidewalks, unless the street is located within 1.5 miles of a school, or 0.5 miles of a greenway, park, or shopping area, in which case a sidewalk shall be required on one side of the street only.

(3) Pedestrian crossings shall be made safer for pedestrians whenever possible by shortening crosswalk distance with curb extensions, reducing sidewalk curb radii, and eliminating free right-turn lanes. Signals that allow longer crossing times in shopping districts, mid-block crossings in high-pedestrians use areas (if well marked and traffic speeds are low), and raised crosswalks and medians shall be provided as appropriate.

(4) Within residential and/or non-residential developments, pedestrian ways, crosswalks, or multi-purpose trails no less than five feet in width, shall be constructed near the center and entirely through any block which is 900 feet or more in length where necessary to provide adequate pedestrian circulation or access to schools, churches, retail stores, personal service establishments, recreational areas, or transportation facilities.

(5) Pedestrian walkways shall form an on-site circulation system that minimizes conflict between pedestrians and traffic at all points of pedestrian access to on-site parking and building entrances. Pedestrian walkways shall connect building entrances to one another and from building entrances to public sidewalk connections and existing or planned transit stops. Pedestrian walkways shall be provided to any pedestrian access point or any parking space that is more than 50 feet from the building entrance or principal on-site destination. All developments that contain more than one building shall provide walkways between the principal entrances of the buildings. All non-residential buildings set back more than 100 feet from the public right-of-way shall provide for direct pedestrian access from the building to buildings on adjacent lots.

(6) Where residential developments have cul-de-sacs or dead-end streets, such streets shall be connected to the closest local or collector street or to cul-de-sacs in adjoining subdivisions via a sidewalk or multi-use path, except where deemed impractical by the Planning Director.

(B) Paths

While not encouraged to substitute for a good system of on-street facilities, multi-use paths may be used to enhance pedestrian and bicycle travel where the existing circulation system does not serve these patrons well, or where abandoned railroads or other open spaces provide corridors free of obstacles. However, all paths shall connect to the street system in a safe and convenient manner, and shall meet the following requirements in addition to the standards contained in the Town's Specification Standards and Details Manual:

(1) All path connections shall be well signed with destination and directional signing.

(2) All paths shall be located in corridors that serve origin and destination points such as residential areas, schools, shopping centers, parks, etc.

(3) All paths shall be built in locations that are visible and easily accessible, for the personal safety of users. The location of asphalt paths shall be in keeping with the Greenways Master Plan.

(4) Whenever possible, paths shall be designed in such a manner that motor vehicle crossings can be eliminated or significantly minimized. Where crossings exist, they must be carefully designed to ensure the safety of the users. In situations where asphalt paths are proposed to run parallel with roadways they shall be offset a minimum of 12' from the back of curb. Asphalt paths will only be permitted parallel to roadways where there are limited number of driveway and street crossings.

(5) All paths shall be constructed of durable, low-maintenance materials, with sufficient width and clearance to allow users to proceed at reasonable speeds. In accordance with the Town's Standard Specification and Details Manual, asphalt paths shall be one 1/2" I-2 underlain by 4" CABC. Generally, paths shall be at least six feet in width. Where multiple uses are intended (i.e., shared pedestrian and bicycle traffic) the path should be ten feet wide whenever possible.

(6) Paths shall be maintained in usable condition throughout the year depending on level of use, including snow removal as appropriate.

7.10.5 Standards for Bicycle Facilities

(A) Bicycle lanes shall be incorporated in the design of all arterial, minor collector, and local streets where low traffic speeds and volumes allow bicyclists and motorists to safely share the road. Sidewalks are not encouraged as substitutes for bike lanes. Bike lanes shall be a minimum of four feet in width (excluding adjacent curb and gutter), and five feet when adjacent to on-street parking.

(B) Consistent with the recommendations of the Cary Comprehensive Transportation Plan, nonresidential development shall provide appropriate bicycle amenities to encourage cyclists. Signage indicating the presence and location of such amenities shall be scaled for easy reading by bicyclists and pedestrians as well as motorists. Bicycle parking shall be provided as part of all high density residential, commercial, retail, office, industrial, and mixed use development where appropriate. Short-term bicycle parking shall be located within 50 feet of a building's main entrance, preferably in a visible and prominent location where there is high pedestrian activity. When there is more than one building on the site, or parking is shared by adjacent sites, bicycle parking must be distributed to serve all buildings or main entrances. Long-term bicycle parking, where appropriate, may be provided on site, or within 500 feet of the site if the parking is secured in one of the following ways:

- (1) In a locked room or area enclosed by a fence with a locked gate.
- (2) Within view or within 100 feet of an attendant or security guard.
- (3) In an area that is monitored by security camera.
- (4) In a location visible from employee work areas.

Section 4.8 Four Model Ordinances to Help Create Physically Active Communities

4.8.1 Model Pedestrian Overlay District (POD) Ordinance

107. Through-Block Connections

Where necessary for public convenience or safety, a developer shall improve and dedicate to the public a [10 to 30]-foot-wide pedestrian and bicycle access way to connect to cul-de-sac streets, to pass through odd-shaped or oversized city blocks [600] feet or longer, to complete existing pedestrian and bicycle routes, and to provide for networks of public paths creating access to schools, parks, shipping centers, transit stops, or other destinations.

Discussion: Additional requirements for or the encouragement of narrower streets or path connections and traffic calming techniques can enhance bicycle and pedestrian activity. These techniques can slow traffic and create a safer environment.

ADDITIONAL CONSIDERATIONS AND TECHNIQUES FOR ENCOURAGING STREET CONNECTIVITY

Needed Actions	Cautions	Possible Incentives
Increase the number of route options.	Be sure to balance the reduction of traffic on arterial streets with increased traffic on residential streets.	Conduct studies to determine the appropriate range in the number of connections to benefit your community. Consider the specific land use characteristics of your community.
Build community support.	Because of the changes in traffic distribution, residents may be concerned about safety and privacy.	Make use of crime-prevention-through-environmental-design techniques.
	Residents may fear that more intersections add noise, compromise their children's safety, and lead to more crime.	Provide for traffic calming techniques.
	Residents may resist required street stubs for extensions of developments because of perceived implications of the development of adjacent property. Additionally, homeowners may purchase a home on a street without knowing that the street has a planned extension.	Educate realtors and residents about the extension of existing street stubs. This can be done through signage at the end of stubs.
Amend Zoning Code /Subdivision Regulations	Various interest groups may be resistant to such changes.	Include connectivity standards or maximum block lengths
	If narrower road widths are a consideration, emergency services may be concerned about the maneuvering of large vehicles.	Permit/require narrower street widths with consideration of emergency needs. Work with emergency services to determine appropriate widths.
	Because of the changes in traffic distribution, residents may be concerned about safety and privacy. Environmental design such as lighting, street calming devices, etc., can deter crime and should be a consideration.	Discourage/ prohibit dead end streets and cul-de-sacs.

Promote and encourage multi-modal transportation options.	Elected officials and residents may not see a need to provide such facilities everywhere, or see them as unnecessary costs.	Provide flexible provisions that allow pedestrian or bicycle connections to be made where topographic or natural features prohibit street extensions. These connections are also important where certain land uses are adjacent or in close proximity to each other, such as schools, parks, and residential areas.
	Neighborhood and property owners may be resistant depending on changes that may be proposed.	Plan for a mix of uses to serve the residents in the surrounding neighborhoods.
	Residents may be concerned about increased traffic and speed on local streets.	Institute provisions for encouraging the use of traffic calming techniques.
	ADA compliance may be an issue. There also may be a need to lessen the standards for those connections that have special physical characteristics.	Provide for proper design for sidewalks and bike paths.
Stimulating Developer Interest	Flexibility may be necessary if site characteristics change or unanticipated events occur.	Institute variance procedures for special circumstances.
	Developers may be concerned about the reduction of usable land because of additional required connections, and the associated potential increase in housing costs or reduced profitability of the development. Residents may oppose any offsetting density increases.	Provide density bonuses for those developments with greater connectivity.
	There may be increased upfront infrastructure costs and impervious cover associated with greater connectivity. Balancing the costs of public street maintenance and the costs of construction is a challenge. However, costs of retrofitting streets to accommodate for congestion are often more expensive.	Provide some exemption from impact fees if developers are making connections that will reduce congestion.

<p>Communicate with Emergency Services</p>	<p>Concern about the cost of maintenance of more public roads may arise. Emergency services may be an ally in education on the benefits of increased access.</p>	<p>Provide education on the benefits of increased emergency vehicle access.</p>
	<p>If narrower road widths are a consideration, emergency services may be concerned about the maneuvering of large vehicles.</p>	<p>Involve emergency services in the planning for street construction, especially for the design of road widths and minimum lengths between the intersections and number of connections necessary.</p>

References:

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