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Bern Grush (2023.09.05)

ISO TC 204/WG 19

Secretariat: ANSI

**Intelligent transport systems – Public mobile robots and similar pathway devices – Part 7: Public mobile robot behaviour on human pathways**

*Systemes de transport intelligents — Robots mobiles pour espaces publics (PMR) et dispositifs de cheminement automatisés — Partie 7: Comportement des robots mobiles publics sur les chemins humains*

**WD**

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CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
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## Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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This document was prepared by Technical Committee ISO/TC 204 WG19.

This is the first edition of this document.

A list of all parts in the ISO 4448 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

As public-area mobile robots (PMRs) multiply in functionality, variety and fleet count, they will occupy an increasing share of, and time within, public pathway space that has been traditionally reserved for active transportation users such as pedestrians, cyclists, micro-mobility users and especially vulnerable road users with mobility challenges.

Such pathways include common footways, cycleways, road shoulders and crosswalks, but also include parking lots that admit human pedestrians, passage ways in public buildings such malls, hospitals, and transportation facilities such as train stations and airports.

These PMRs may perform any number of tasks that may be for delivery, maintenance, security or other purposes.

For this, we require a body of rules to guide PMR mobility behaviour among other users of pedestrianized spaces. Such rules would address matters ranging from speed and priority to specific methods to enter, exit, and traverse specific kinds of infrastructure.

The closest analogy to this is the “rules of the road” that are embodied in legal codes for motor vehicles—the types of rules that a driver must learn in order to drive a common motor vehicle.

# Intelligent transport systems – Public mobile robots and similar pathway devices – Part 7: Public mobile robot behaviour on human pathways

## 1 Scope

This document is Part 7 of the 4448 series and addresses the “Rules of the road” for public area mobile robots (PMRs) traversing on, or operating within, public, pedestrianized spaces or *pathways*.

Pathways include common, outdoor footways, cycleways, road shoulders and crosswalks, but also include passage ways in public buildings such malls, hospitals, and transportation facilities such as train stations and airports, as well as parking lots that admit human pedestrians. To fully generalize—any public space which admits both human use (without a motor vehicle) and mobile robot use, such that the humans admitted can be any of inattentive, uninvolved, unprotected, or untrained regarding the use or activity of the mobile robot(s).

The definition of what is in or out of scope relies on the presence or absence of *non-involved humans* within the range of potential harm, disruption or alarm from the activity of the robot.

Out of scope are the behaviours for:

- Non-mobile (fixed or tethered) robots
- Public-service mobile robots during emergency operations
- Personal mobile robots operating within private residential or non-public business spaces (examples would be an in-home vacuum cleaner or an office delivery robot or washroom cleaner)
- Mobile robots operating in a factory, farm, warehouse, or other working environment where humans are physically present to collaborate with or supervise the robots (for example, a robotic lawnmower supervised by a maintenance worker is out of scope while it is operating with no proximate human excepting the maintenance worker responsible; however, if that same robot were to move from one work area to another by way of a public footway that may admit non-involved humans at the same time, then its behaviours are within the scope of this standard)

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Urban Street Design Guide, NACTO: <https://nacto.org/publication/urban-street-design-guide/street-design-elements/sidewalks/> (Accessed October 2022)

<https://planningtank.com/transportation/traffic-island> (not sure needed?)

<https://www.gov.uk/government/consultations/review-of-the-highway-code-to-improve-road-safety-for-cyclists-pedestrians-and-horse-riders/summary-of-the-consultation-proposals-on-a-review-of-the-highway-code> (not sure needed)

### 3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO/TS 14812:2022 and in ~~4448-2~~ apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

#### 3.1

##### **block-face**

extent of sidewalk/pavement on one side of a street between two consecutive intersections crossing that street

#### 3.2

##### **footway**

##### **footpath**

pavement

sidewalk

lane primarily designed for the movement of pedestrians

Note 1 to entry: A paved footway is called a "pavement" in British English.

Note 2 to entry: Regulations typically allow footways to be used by other ultra-low speed users, such as the users of wheelchairs and strollers.

[SOURCE: ISO/TS 14812:2022, 3.3.3.3]

#### 3.3

**xxx**

xxx

#### 3.4

**xxx**

xxx

#### 3.5

**xxx**

xxx

#### 3.6

**xxx**

xxx



## 4 Rules and Procedures

There are several groups of PMR rules:

- Rules for PMR Behaviour while Operating within a walkway segment (Block-face, hallway, footway)
- Rules for PMR Behaviour while Operating within a Cycleway or Auxiliary Lane

The forms of each rule type will follow a rigid formulation (with some exceptions).

### 4.1 Rules for PMR Behaviour while Operating within a walkway segment

The phrases “a PMR shall”, “a PMR will”, or “a PMR should” implies the “operator” immediately responsible for said PMR. In the case of a fully automated device, “PMR behaviour” is referring to the automated intelligence within that device (the “operator” of its immediate movement decisions). In the case of a teleoperated device, “PMR behaviour” is referring to the obligations of the human operator responsible for supervising the movements of that device.

#### 4.1.1 General Pathway Behaviour Rules

The assignment of travel-use of a Pathway is made by the Orchestration Manager when it grants a Trip Plan to a Fleet Operator. This means that a PMR can only arrive at a travel segment by assignment. Specifically, it cannot elect to use (occupy) and public space without some form of controlled permission in the same way that an airplane cannot land at an arbitrary time and place without some type of permission.

This section of the draft standard needs review and expansion. It is currently written in terms of pedestrian footways on city block-faces, but it will be expanded to include cycleways, roadways and other pathways.

- The managing jurisdiction shall determine whether PMRs are to travel only clockwise or counter-clockwise on block-faces. This is determined by travelDirection, [4448-2: Table 6], and is determined segment by segment and is not fixed over an entire jurisdiction.
  - For jurisdictions where the Prevailing Traffic Side is the right side, counter-clockwise is recommended as that means PMRs will primarily be traveling on the outer edge of the Pedestrian Through Zone.
    - This avoids conflicts with shorelining by people who are blind
  - For countries where the Prevailing Traffic Side is the left side, clockwise is recommended
- At crosswalks, PMRs shall travel on Intersection Side of the crosswalk
  - For countries that drive on the right, this results in CW circulation around the intersection

The **Pedestrian Through Zone** is the portion of the sidewalk intended for pedestrian travel-through. At intersections, this is often delineated by the curb ramp of the sidewalk. It may also be delineated as the part of the sidewalk encompassed by the linear extension of the crosswalk or an extension of the paved portion of the sidewalk. (Should this paragraph be integrated into the definitions?)

#### 4.1.2 General Cycleway Behaviour Rules

Cycleways present PMRs with an environment with a different set of rules and behaviours from pathways. In cycleways, vehicles are expected to travel at faster speeds and to indicate their travel intentions using signals. Cycleways are generally narrower than pathways and don't have areas where users can move out of the flow of traffic to pullover and wait. In addition, there are PMRs designed to primarily travel in cycleways that are significantly larger than those operating primarily on footways.

Behaviours for PMRs operating in cycleways emulate those currently employed by cyclists.

### 4.1.3 General Service Lane Behaviour Rules

TBD



Figure 1: Sidewalk Zones (Source: NACTO)

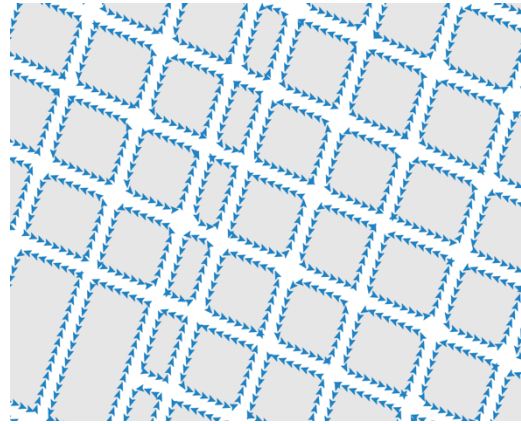


Figure 2: PMR Block-Face Circulation with a Right-Sided Prevailing Traffic Side

## 4.2 General PMR Procedures

### 4.2.1 General Motion Procedures

#### 4.2.1.1 Waiting for a Short Period of Time

When a PMR needs to wait for a short period of time, such as when at an intersection or briefly stopped by an obstruction, the PMR shall employ procedure PMRWaitShort defined as follows:

- **IF** in motion,
  - **THEN** the PMR shall employ procedure PathwayStopping
- The PMR shall use signal WaitShort

#### 4.2.1.2 Waiting for a Long Period of Time

When a PMR needs to wait for a long period of time, such as when loading/unloading or waiting for a new Trip Plan, the PMR shall employ procedure PathwayWaitLong defined as follows:

- **IF** in motion,
  - **THEN** The PMR shall employ procedure PathwayStopping
- The PMR shall use signal WaitLong

#### 4.2.1.3 Initiating Movement

When a PMR needs to initiate motion after waiting, the PMR shall employ procedure PMRStarting defined as follows:

- The PMR shall use signal StartMotion
- The PMR shall gradually accelerate to the appropriate Speed
- The PMR shall attempt to preserve *shyDistanceDynamic* distances throughout the maneuver

## 4.2.2 Interacting With Infrastructure Procedures

### 4.2.2.1 Entering an Elevator

When a PMR needs to use an elevator, the PMR shall employ the procedure PathwayElevatorEnter defined as follows:

- The PMR shall ~~electronically activate~~ request the elevator
- The PMR shall employ the procedure PathwayWaitShort at a Waiting Area defined as follows:
  - Outside of any Pedestrian Through Zones, in particular away from the one extending out perpendicular from the elevator doorway
  - At least  $2 * ShyDistanceStandBack$  from elevator buttons
  - A location from which the PMR can accurately detect the number of passengers in the elevator
- **IF** the elevator has enough space so that the PMR does not violate *ShyDistanceDynamic*
  - **THEN** the PMR shall employ the procedure PathwayStarting **AND** enter the elevator.

### 4.2.2.2 Traversing a Parking Gate

TBD

### 4.2.2.3 Traversing a Sliding Door

TDB

## 4.3 PMR Procedures

### 4.3.1 Pathway Motion Procedures

#### 4.3.1.1 Stopping

When a PMR needs to stop, the PMR shall employ procedure PathwayStopping defined as follows:

- The PMR shall gradually decelerate to a stop
- The PMR shall stop at a location that is:
  - At least *shyDistanceStatic* from street furniture and buildings **AND**
  - At least *shyDistanceDynamic* from stationary objects **AND**
  - At least *shyDistanceStandBack* from waiting pedestrians **AND**
  - Conforms to any situational conditions

#### 4.3.1.2 Default Travel

While traveling on a pathway under normal conditions, a PMR will employ the procedure PathwayTravelDefault defined as follows:

- The PMR shall travel in a direction on a blockface according to the *travelDirection* [4448-2, Table xx]
- The PMR will follow other sidewalk users no closer than  $4 * shyDistanceStandBack$ <sup>1</sup>
- **IF** *travelSide* is not defined,
  - **THEN** the PMR shall travel at *accessFootMaxSpeed* in the **Pedestrian Through Zone** on the **Prevailing Traffic Side**.
- **ELSE IF** *travelSide* is defined,

---

<sup>1</sup> Should this be modified to something shorter when a PMR is crossing an intersection? This might be too big.

- **THEN** the PMR shall travel on a side of a blockface according to *travelSide* [4448-2, Table xx]

#### 4.3.1.3 Reversing Direction

In the event that a PMR must reverse direction, it shall employ the procedure PathwayReverseDirection defined as follows:

- The PMR shall employ procedure PathwayStopping, including its required signals
- The PMR shall reverse direction in as small an area as possible **WHILE** using signal ReverseDirection
- The PMR shall employ procedure PathwayStarting, including its required signals

#### 4.3.1.4 Overtaking

If a PMR encounters a slow-moving Pedestrian, it may employ procedure PathwayTravelOvertake defined as follows:

- **IF** the Pedestrian is traveling slower than the *robotOvertakeSpeed (4448-2, Table \_\_)* **AND**
  - **IF** there are no Pedestrians within  $15 * \text{ShyDistanceDynamic}$  traveling in the opposite direction in the space where it wishes to overtake
  - **THEN** the PMR may overtake at *shyDistanceDynamic* from the **Pedestrian** traveling at *accessFootMaxSpeed*

#### 4.3.1.5 Immobilized

If a PMR is unable to move, it shall perform the procedures ImmobilizedAlert defined as follows:

- **IF** the PMR is still able to communicate
  - **THEN** the PMR shall report the immobilization and the cause to the Fleet Operator and Orchestration Manager
- **IF** at least some of the PMR's signalling systems still function
  - **THEN** the PMR shall perform signal Emergency

#### 4.3.1.6 Fire

If a PMR detects a fire onboard, it shall perform the procedures EmergencyFire defined as follows:

- **IF** the PMR can still move
  - **THEN** the PMR shall perform the procedure PathwayPullover or AuxiliaryPullover
- **IF** the PMR is still able to communicate
  - **THEN** the PMR shall report the fire and the cause to the Fleet Operator and Orchestration Manager
- **IF** at least some of the PMR's signalling systems still function
  - **THEN** the PMR shall perform signal EmergencyFire corresponding to the type of fire detected

### 4.3.2 Crossing Procedures

#### 4.3.2.1 Approaching a Crossing

When approaching a crossing, a PMR will employ the procedure PathwayApproachCrossing defined as follows:

1. The PMR approaches an intersection cautiously at the lower limit of assigned speed on that segment
2. The PMR recognizes of the level of pedestrian activity at a crossing
3. The PMR recognizes of the geometry of the crossing

4. The PMR recognizes any designated Waiting Areas at the crossing
5. The PMR recognizes the current availability of space in Waiting Areas at the crossing

#### 4.3.2.2 Waiting at a Crossing

When waiting at a crossing with Waiting Areas, a PMR will employ the procedure PathwayWaitCrossing defined as follows:

1. **IF** there is a defined Waiting Area **AND** the Waiting Area has room for the PMR,
  - **THEN** the PMR shall employ the procedure PathwayWaitShort at the **Waiting Area**
2. **ELSE IF** a Waiting Area does not have room for the PMR,
  - **THEN** the PMR shall employ the procedure PathwayWaitShort at another **Waiting Area** near the intersection
3. **ELSE IF** there are no Waiting Areas that have room for the PMR **OR** none exist,
  - **THEN** the PMR shall perform the procedure PathwayWaitShort at an area of the sidewalk nearest to the curb that is free of pedestrians **AND** outside of the **Pedestrian Through Zone (Figure 1)**

#### 4.3.2.3 Entering a Crossing

When entering a crossing, a PMR will employ the procedure PathwayCrossingEnter defined as follows:

1. The PMR shall begin crossing only:
  - **IF** conflicting vehicles at the crossing have recognized its presence **OR** Pedestrians waiting to cross have already begun crossing **AND**
  - **IF** the traffic signals/signs indicate it is appropriate to do so **AND**
  - **IF** it is certain it has a clear travel path in that intersection **AND**
  - **IF** the PMR has not received an emergency vehicle signal
2. The PMR shall employ procedure PathwayStarting to *accessFootMaxSpeed*

#### 4.3.2.4 Crossing a Roadway

When crossing a roadway, a PMR will employ the procedure PathwayCrossingDefault defined as follows:

- **IF** the PMR's path is clear of Oncoming Users within  $5 * shyDistanceStandback$ 
  - **THEN** the PMR shall perform PathwayTravelDefault
- **ELSE** the PMR shall decelerate to  $0.5 * accessFootMaxSpeed$

#### 4.3.2.5 Hustle Across a Roadway

Some rare situations may require the PMR to clear the intersection in a short amount of time. For these situations, a PMR will employ the procedure PathwayCrossingHustle defined as follows:

- The PMR shall verify that it has a clear path to the other side with no people or objects within *shyDistanceDynamic* of its path
- The PMR shall indicate is hustling using signal PathwayHustle
- The PMR shall travel at *accessAuxMinSpeed*
- Within *shyDistanceDynamic* of the kerb, the PMR shall decelerate to *accessFootMaxSpeed*

#### 4.3.2.6 Completing a Crossing After Obstruction

In the event any obstacle (e.g., a motor vehicle) blocks the marked crosswalk after the PMR has entered the crosswalk, a PMR will perform PathwayCrossingObstructed defined as follows:

- The PMR shall wait for the obstruction to clear
- **IF** the PMR detects no people or objects within *shyDistanceDynamic* of its path **AND** the remaining crossing is greater than  $4 * shyDistanceStandBack$ 
  - **THEN** the PMR shall perform procedure PathwayCrossingHustle
- **ELSE** the PMR shall perform PathwayCrossingDefault

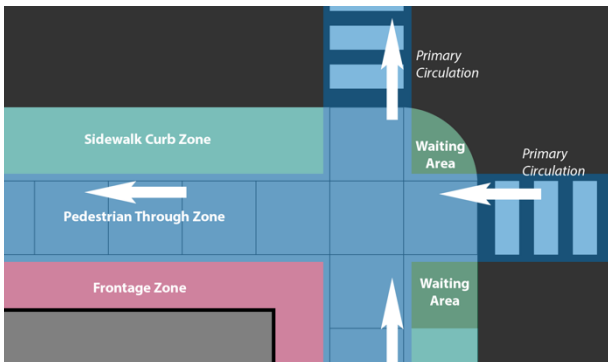


Figure 3: PMR Circulation at an intersection crossing

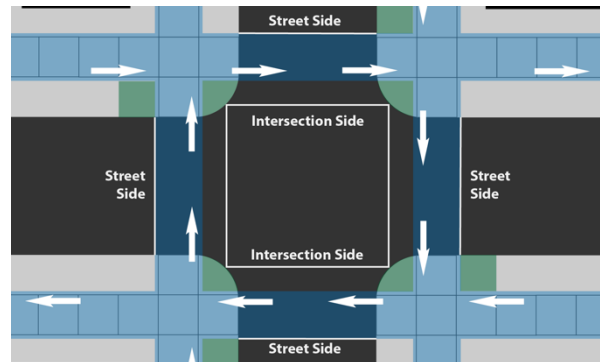


Figure 4: PMR Circulation Around an Intersection

#### 4.3.2.7 Traveling Outside the Boundary of a Crosswalk

TBD

#### 4.3.2.8 Reversing While Crossing an Intersection

TBD



Figure 5: Two examples of Intersections without defined waiting areas, but with space for waiting areas. Caution, these examples are in fair-weather and without pedestrians

#### 4.3.2.9 Exiting a Crossing

When exiting an intersection, a PMR will employ the procedure PathwayCrossingExit defined as follows:

- A PMR shall only exit an intersection in a way that conserves *shyDistanceDynamic* distance
- **IF** the PMR needs to make another crossing **AND**
  - **IF** the curb ramp or its edge is unoccupied,
    - **THEN** the PMR shall employ the procedure PathwayWaitShort at the curb ramp or its edge.
  - **ELSE IF** it is occupied,
    - **THEN** the PMR shall employ PathWaitIntersection procedure

#### 4.3.2.10 Clearing an Emergency Situation

There may be situations such as an approaching emergency vehicle or a sudden rush of pedestrians that may force a PMR to rapidly clear the intersection and stop. In these situations, a PMR shall perform the procedure PathwayGetOutOfWay defined as follows:

- **IF** the PMR is in an intersection,
  - **THEN** it shall perform the procedure PathwayCrossingHustle to clear the intersection
- The PMR shall perform the procedure PathwayStopping
- The PMR shall perform the procedure PathwayWaitLong **UNTIL** Fleet Operator or Orchestration Manager gives All Clear message

#### 4.3.2.11 Encountering a Broken Signal

If a PMR encounters a damaged traffic or crossing signal, it shall perform the procedure BrokenSignal defined as follows:

- **IF** the PMR can switch to teleoperation,
  - **THEN** the PMR switch to teleoperation
  - **IF** there is an officer directing traffic,
    - **THEN** the teleoperator shall perform PathwayCrossingEnter according to the signals of the traffic officer
  - **ELSE** the PMR shall perform the procedure PathwayWaitLong **AND** request a new trip plan from the Orchestration Manager
- **ELSE** the PMR shall perform the procedure PathwayWaitLong **AND** request a new trip plan from the Orchestration Manager

### 4.3.3 Transit Stop Procedures

A PMR shall not make transit users feel unsafe or inconvenienced when passing by a transit stop.

For the purpose of the rules below, a Transit Zone is defined as the area encompassing a transit stop where passengers can be expected to wait or disembark. **In the case where Transit Zones are not defined (geofenced), they will be the portion of the sidewalk extending 10m radius (we need a regional variable in 4448-2, not a fixed value) from the front face of the transit stop sign/shelter. Do we need to add transit map data on the SSLR codes?**

#### 4.3.3.1 Approaching a Pathway Activity Zone

When exiting a **Pathway Activity Zone**, a PMR will employ the procedure PathwayApproachActivityZone defined as follows:

- **IF** a PMR is approaching a **Pathway Activity Zone** **AND**
  - **IF** it determines there are no **Pedestrians**, vehicles or vendor stands present,
    - **THEN** it may enter employing procedure PathwayTravelDefault
- **ELSE IF** the sidewalk has a **Pathway Activity Zone** outside of the **Pedestrian Through Zone** **AND**
  - **IF** **Pedestrians**, transit vehicles or vendors stands are present,
    - **THEN** it may enter the Pathway Activity Zone employing procedure PathwayTravelCaution [4448-2, Table 5]
- **ELSE IF** the sidewalk only has a **Pedestrian Through Zone** **AND**
  - **IF** there are **Pedestrians**, transit vehicles or vendor stands present,
    - **THEN** it may not enter the Pathway Activity Zone (**Figure 7**). **AND**
    - **THEN** employ procedure **xxxxx**

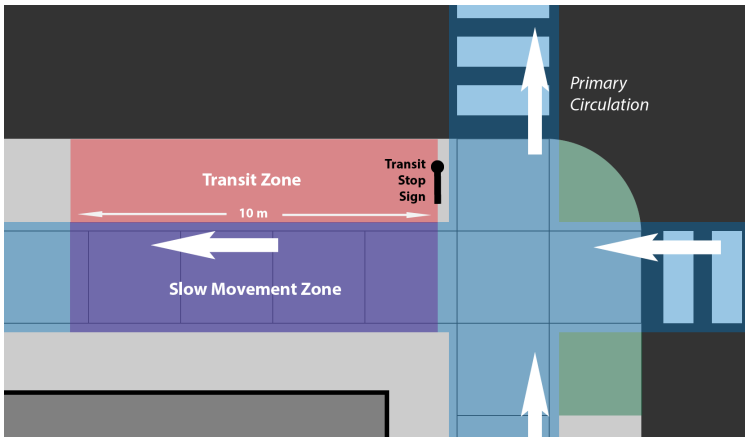


Figure 6: PMR Circulation at Transit Stop Example



Figure 7: Example of a spontaneous Transit Stop situation that a PMR shall not pass through.

#### 4.3.4 Travel along a Block-face

While traveling on a pathway under normal conditions, a PMR will employ the procedure PathwayTravelDefault defined as follows:

- The PMR shall travel in a direction on a blockface according to the *travelDirection* [4448-2, Table xx]
- **IF** *travelSide* is not defined,
  - **THEN** the PMR shall travel at *accessFootMaxSpeed* in the **Pedestrian Through Zone** on the **Prevailing Traffic Side**.
- **ELSE IF** *travelSide* is defined,
  - **THEN** the PMR shall travel on a side of a blockface according to *travelSide* [4448-2, Table xx]

##### 4.3.4.1 Travelling on a Block-Face with Potential Pedestrian Conflicts

A PMR may have to travel on a pathway under conditions where conflicts with Pedestrians may be more likely, such as areas of the sidewalk adjacent to street parking, loading zones or patios. In these situations, a PMR will employ the procedure PathwayTravelCaution defined as follows:

- The PMR shall travel at  $0.5 * accessFootMaxSpeed$  WHILE using signal TravelCaution
- **IF** necessary (*possible?*), the PMR shall travel at *shyDistanceDynamic* from the Sidewalk Zone that has Pedestrian activity

##### 4.3.4.2 Reversing Direction on a Block-Face

In the rare case that a PMR needs to reverse direction on a block-face, the PMR shall employ procedure PathwayReverseBlockFace defined as follows:

- The PMR shall find an appropriate place to stop outside of the **Pedestrian Through Zone**.
- **IF** the PMR can stop outside the **Pedestrian Through Zone**,
  - **THEN** the PMR shall employ procedure PathwayStopping outside the Pedestrian Through Zone
  - **THEN** the PMR shall perform the procedure PathwayReverseDirection
- **ELSE IF** the PMR cannot stop outside the Pedestrian Through Zone,
  - **THEN** it must perform the procedure PathwayReverseDirection.



#### 4.3.4.3 Waiting when Passage is Blocked

When a PMR encounters a blocked passage on a block-face, the PMR shall employ procedure PathwayWaitBlocked defined as follows:

- The PMR shall perform the procedure PathwayWaitShort outside the **Pedestrian Through Zone** **IF** possible
- **IF** the passage does clear within *robotWaitForClearway* minutes,
  - **THEN** perform procedure PathwayStarting
- **ELSE IF** the passage does not clear within *robotWaitForClearway* minutes,
  - **THEN** the PMR shall move to the side of the sidewalk (preferential order being [1] Sidewalk Curb Zone [2] Frontage Zone and [3] Side of the Sidewalk)
  - **THEN** request a new route from the **Orchestration Manager**
  - **THEN** perform procedure PathwayWaitLong
  - **THEN** report incident to **Orchestration Manager**

#### 4.3.4.4 Encountering an Oncoming Pedestrian

While traveling, a PMR may encounter a sidewalk user approaching it within its current path of travel. In order to avoid a collision, the PMR shall perform the procedure PathwayTravelOncoming:

- At  $5 * shyDistanceStandback$  from the Oncoming User, the PMR shall use signal WarningFar
- **WHILE** the Oncoming is still traveling towards the PMR within the PMR's travel path,
  - **THEN** At  $3 * shyDistanceStandBack$ , the PMR shall decelerate to  $0.5 * footMaxSpeed$  **AND** use signal WarningNear
  - **THEN** At *shyDistanceStandBack*, the PMR shall stop **AND** use signal Shout

#### 4.3.4.5 Approaching A Narrow Passage on a Block-Face

A narrow passage is a section of a section of sidewalk that is too narrow for two users to concurrently and safely pass one another. This narrow passage may be formed by trees, street furniture, temporary objects or Pedestrians standing on the sidewalk. If a PMR approaches a narrow passage, the PMR shall perform procedure PathwayWaitNarrow defined as follows:

- **IF** there are no **Pedestrians** nearby,
  - **THEN** the PMR shall perform procedure PathwayTravelCaution
- **ELSE IF** there are Pedestrians nearby,
  - **THEN** the PMR shall perform procedure PathwayWaitBlocked

#### 4.3.4.6 Pulling over after Encountering a Breakdown in a Pathway

When a PMR encounters a breakdown (machine or communications failure), the PMR shall employ procedure PathwayPullover defined as follows:

- **IF** in motion **OR** in Pedestrian Through Zone,
  - **THEN** The PMR will move into the following zones in order of preference:
    - 1) Sidewalk Curb Zone
    - 2) Frontage Zone
    - 3) Traffic side of Pedestrian Through Zone
  - **THEN** The PMR shall employ procedure PathwayStopping
- The PMR shall report the issue to the Orchestration Manager if possible
- The PMR shall use signal WaitLong if possible

### 4.3.5 Traffic Islands

#### 4.3.5.1 Channelizing Island

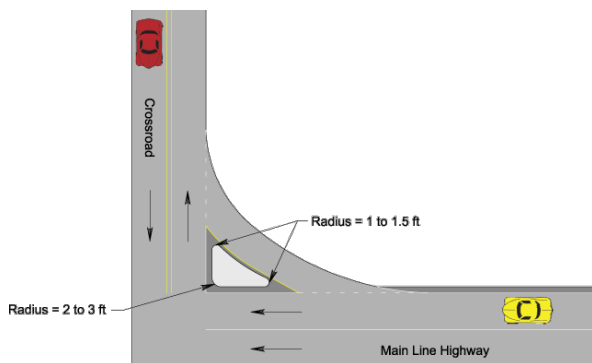
A Channelizing Island is often used to guide right-turn traffic away from adjacent through movement. (**Figure 8**). At these locations, the PMR will perform the procedure PathwayCrossingChannelizing defined as follows:

- At the street side curb, the PMR shall perform the procedure PathwayCrossingWait
- The PMR shall perform procedure PathwayCrossingEnter and PathwayCrossingDefault
- The PMR shall perform procedure PathwayCrossingWait in the Channelizing Island

#### 4.3.5.2 Refuge Island

A Refuge Island, also known as a pedestrian refuge or pedestrian island, is a small section of pavement or sidewalk surrounded by roadway infrastructure, where pedestrians can stop before completing a road crossing. (**Figure 9**). At these locations the PMR shall perform the procedure PathwayCrossingRefuge defined as follows:

- **IF** the PMR is unable to complete the crossing of a street in one cycle **AND** the crossing is clear of pedestrians **AND** the refuge island has enough space to accommodate a PMR at *shyDistanceStatic* from any PMR that happens to be there.
  - **THEN** the PMR may perform the procedures PathwayCrossingExit **AND** PathwayCrossingWait



**Figure 8:** Channelizing Island (Source: SDDC)



**Figure 9:** Refuge Island (Source: Traffic Choices)

### 4.3.6 Roundabouts

Roundabouts pose a unique challenge as usually there are no dedicated signals allowing pedestrians to travel. Normally, vehicular traffic is supposed to yield to any pedestrians crossing.

#### 4.3.6.1 Crossing a Roundabout

When a PMR must cross a roundabout, it shall perform the procedure PathwayCrossingRoundabout defined as follows:

- **IF** the roundabout has an area specifically suited to pedestrians,
  - **THEN** the PMR shall use these for crossing.
- **IF** there is a clear opening in the traffic flow (a PMR must have a sufficient line of sight on the curved roadway)
  - **THEN** the PMR shall perform procedures PathwayCrossingEnter **AND** PathwayCrossingDefault
- **ELSE** the PMR shall perform procedures PathwayCrossingWait, PathwayCrossingEnter **AND** PathwayCrossingDefault

### 4.3.7 Pickup/Dropoff (PUDO) and Task Execution Areas

#### 4.3.7.1 Waiting for Pickup or Dropoff (Footway)

PMRs that are making deliveries normally wait at the building or doorway of the origin or destination of their task. There may be other possibilities at a later date once PMRs are ambulatory, or include stair-climbing features. This version of the draft considers only wheeled PMRs that may be able to climb a curb but would likely not be able to climb steps.

For pickup/dropoff, the PMR shall perform procedure PathwayPUDO defined as follows:

- **IF** a Pickup/Dropoff area zone (PUDO) has been designated,
  - **THEN** the PMR shall wait at the designated PUDO.
- **ELSE IF** a PUDO has not been designated,
  - **THEN** the PMR shall wait at a proximate location according to this order of preference:
    - In the Sidewalk Curb Zone **AND** not within  $2 \cdot shyDistanceStandBack$  of a **PathwayActivityZone**
    - In the Frontage Zone of the Destination clear of any doorways **AND**  $shyDistanceStatic$  from its property walls or fence [this may be an issue for shorelining.]
    - Just off the edge of the pavement in the case of no specific sidewalk curb zone or frontage zone
    - At the very edge of the pavement in the event it is not possible to wait just off the edge
- The PMR shall use signal WaitLong

#### 4.3.7.2 Waiting for Pickup or Dropoff (Cycleway) *CyclewayWaitPUDO? (Lee dropped this?)*

- A PMR shall not wait in a Cycleway. If a PMR must stop at a location along a segment, then it must traverse that segment outside of any Cycleway. Paragraph (5.7.2.2) describes how a PMR may exit a bike away and enter a sidewalk in order to stop at such locations.
- *(this needs more work; how to handle PMRs designed for bikeways and too large for sidewalks?)*

#### 4.3.7.3 Waiting for Pickup or Dropoff (roadway) *RoadwayWaitPUDO? (Lee dropped this?)*

- A PMR that is designed to use a roadway, or a roadway shoulder, will be too big to wait on a sidewalk and shall not wait in a Cycleway. If a PMR must stop at a location along a roadway segment, then it shall position itself at the edge of the roadway or on the roadway shoulder in a way or location that is least likely to impede motor or cycle traffic.

#### 4.3.7.4 Performing a Task at a Location

A PMR executing a task on a sidewalk such as snow plowing or street cleaning shall perform the procedure PathwayExecutingTask defined as follows:

- Prior to executing a task on a sidewalk, the PMR must use signal StartTask,
- Before starting a service task, the PMR shall ensure that  $shyDistanceStandBack$  in front of the PMR is clear
- **WHILE** performing a task, the PMR must use the appropriate signal indicating it is performing a task. (These are detailed in 4448-8).
  - PMRs shall perform their task in a regular, predictable manner so that humans can understand how to avoid harm or interference.
  - **IF** a pedestrian, nonhuman animal, or other PMR is closer than  $shyDistanceStandBack$  of the PMR,

- **THEN** the PMR shall pause its task. It may use the *Pardon* signal to prompt the person, animal or PMR to move **OR** it may need to inform its Fleet Operator of the matter. (This is not a matter for the Orchestration Manager.)

#### 4.4 Rules for PMR Behaviour while Operating within a Cycle Lane or Auxiliary Lane

When describing motion of the PMR between the sidewalk and cycle lane, the terms mount/dismount will be used. This is to distinguish motion between the cycle lane and the roadway.

##### 4.4.1 Entering and Exiting Cycle Lanes

When a PMR enters/exits a cycle lane, it shall do so safely according to procedure *AuxiliaryEnterExit* defined as follows:

- The PMR shall only enter/exit a cycle lane if it can verify that it is clear.
- The PMR shall signal before entering/exiting a Cycleway and as it is entering the Cycleway (do these signals need to be defined?)

##### 4.4.2 Intersections

###### 4.4.2.1 Mounting A Cycle Lane at an Intersection

When a PMR mounts a cycle lane from a sidewalk, it shall perform procedure *AuxiliaryMountIntersection* defined as follows:

- The PMR shall mount the cycle lane on the downstream side of the intersection in its direction of travel. This reduces the probability of a PMR of blocking the crosswalk or intersection
- The PMR shall join the cycle lane when traffic on the cycle lane has been stopped
- The PMR shall perform procedure *AuxiliaryEnterExit*

###### 4.4.2.2 Dismounting A Cycle Lane at an Intersection

When a PMR dismounts a cycle lane to the sidewalk, it shall perform procedure *AuxiliaryDismountIntersection* defined as follows:

- The PMR shall leave a cycle lane to enter a sidewalk on the upstream side of the intersection in its direction of travel. This reduces the probability of a PMR of blocking the crosswalk or intersection and reduces the speed differential between cycle traffic and a slowing PMR
- The PMR shall endeavour to travel at or near *accessFootMaxSpeed* as it mounts the sidewalk
- The PMR shall perform procedure *AuxiliaryEnterExit* as it leaves the cycle lane

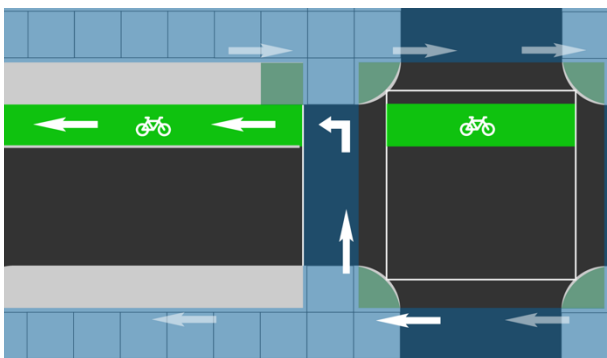


Figure 10: PMR Mounting a Cycle Lane

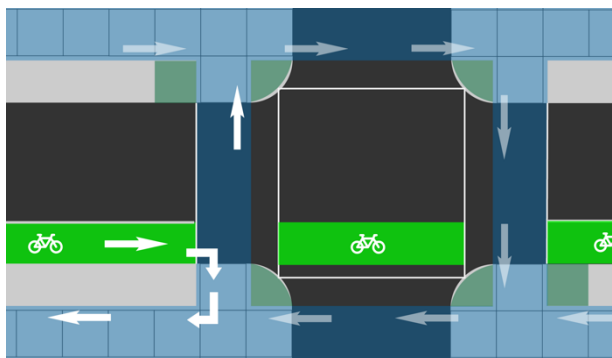


Figure 11: PMR Dismounting a Cycle Lane

#### 4.4.2.3 Waiting at an Intersection

When a PMR in a cycle lane waits at an intersection, it shall perform procedure AuxiliaryWaitIntersection defined as follows:

- The PMR shall wait in a queue like other rule-abiding users of the cycle lane
- The PMR shall wait in areas where it is appropriate for other cycle lane users to wait
- The PMR shall not jockey for position in such a waiting queue. Cyclists are likely to do so.
- The PMR shall always allow cycle users to take precedence;

#### 4.4.2.4 Crossing a Signalized Intersection

Regardless of the rules described here, a PMR shall always act in a way that gives right-of-way to other cyclists and pedestrians and always behaves in a safe manner regarding itself and other vehicles.

At signalized intersections, a PMR shall perform the procedure AuxiliaryCrossingSignalized defined as follows:

- The PMR shall only cross an intersection when a traffic light or cycle lane signal indicates it is appropriate to do so
- The PMR shall not enter an intersection after its automated traffic signal has changed to amber.

#### 4.4.2.5 Crossing a Unsignalized Intersection

At unsignalized intersections, a PMR shall perform the procedure AuxiliaryCrossingUnsignalized defined as follows:

- **IF** Idaho Stops are permitted,
  - **IF** the intersection is clear,
    - **THEN** a PMR is only required to slow down as it approaches the intersection and may cross without stopping
- **ELSE IF** Idaho Stops are not permitted,
  - **THEN** a PMR shall behave according to cycling rules and cross when it is safe and appropriate to do so

### 4.4.3 Mid-lane in a Cycleway

#### 4.4.3.1 Overtaking in a Two-Way Cycleway

If a PMR encounters a slow-moving vehicle in a two-way cycle lane, it may overtake according to the procedure AuxiliaryOvertakingTwoWay defined as follows:

- **IF** there is only one bicycle in front of the PMR is travelling at less than *accessAuxMinSpeed* **AND** The Cycleway is clear in the opposite direction for at least *viewingDistance* **AND** no other Cycleway users behind it are attempting an overtake
  - **THEN** a PMR may overtake by:
    - Using signal CycleOvertake
    - Accelerating up to *accessAuxMaxSpeed*
    - Re-entering the cycle lane going in the same direction with at least *spacingInterval\*accessAuxMinSpeed* distance between it and the passed vehicle

#### 4.4.3.2 Passing an Obstruction in a Cycleway

In situations where a cycleway is obstructed completely, the PMR shall follow the procedure AuxiliaryObstruction defined as follows:

- **IF** a PMR is capable of mounting the kerb,
  - **THEN** it may dismount the Cycleway and enter the sidewalk performing procedure AuxiliaryMountDismountMidblock

- **ELSE IF** a PMR is not capable of mounting the kerb **AND** there is no kerb or physical barrier between the cycleway and the roadway **AND** the roadway is clear of vehicular traffic,
  - **THEN** the PMR may temporarily enter the roadway using procedure AuxiliaryEnterExit
- **ELSE IF** none of the above conditions can be satisfied **AND** the cycleway is two-way,
  - **THEN** the PMR may turn around and travel in the opposite direction in the same Cycleway as long as it is safe to do so, performing procedure PathwayReverseDirection
- **ELSE IF** none of the above conditions can be satisfied,
  - **THEN** the PMR shall signal its circumstance to its Fleet Operator
- In all these cases, the Fleet Operator shall report the obstruction to the Orchestration Manager  
*(Add this to -20 JDR?)*

#### 4.4.3.3 Mounting or Dismounting a Cycleway Mid-Block-Face

A PMR shall avoid entering or leaving a Cycleway except at intersections. All trip planning by a Fleet Operator shall avoid such mid-block departures. If this is required for an unavoidable reason or municipalities allow for mid-block mounting/dismounting, then it shall happen as follows according to procedure AuxiliaryMountDismountMidblock defined as follows:

- **IF** the PMR does not have any closely following traffic **AND** there is an extended opening so it can fully execute entry/exit and reach its cruising speed, *(how is "extended" to be judged?)*
  - **THEN** a PMR shall perform procedure AuxiliaryEnterExit swiftly and optimally **AND** use signal Pardon

*NOTE: Municipalities must have the flexibility to determine if mid-lane mounting/dismounting is allowed. We will need a new entry for 4448-2*

#### 4.4.3.4 Pulling over after Encountering a Breakdown in a Cycle Lane

When a PMR encounters a breakdown (machine or communications failure), the PMR shall employ procedure AuxiliaryPullover defined as follows:

- **IF** in motion **OR** in a Cycle Lane,
  - **THEN** The PMR will move into the following zones in order of preference:
    - 1) Pathway Waiting Area
    - 2) Cycle Lane Buffer
    - 3) Sidewalk Curb Zone
    - 4) Frontage Zone
    - 5) Prevailing traffic side edge of the Cycle Lane
  - **THEN** The PMR shall employ procedure PathwayStopping
- The PMR shall report the issue to its Fleet Manager *(should it be reported through to the OM?)*
- The PMR shall use signal WaitLong if possible

#### 4.4.4 Passing a Transit Stop

These rules apply for situations where a Cycleway runs past a transit stop.

##### 4.4.4.1 Cycle Lane Between Transit Stop and Sidewalk

When a PMR travels on a cycle lane located between a Transit Stop, it shall follow the procedure AuxiliaryTransitStopSidewalkside defined as follows:

- The PMR shall travel at *accessAuxMinSpeed* while traveling within the Transit Stop area
- The PMR must yield to pedestrians crossing the Cycleway to and from the transit stop
- The PMR must position itself **[on the extreme travelSide]** and when there is a transit vehicle at the transit stop it shall stop at *5\*shyDistanceStandback* before the transit stop *(such a distance rule may need to be flexible in the case that such a distance places the PMR in an intersection, or other inappropriate location).*
- See Figure 12

#### 4.4.4.2 Cycle Lane Between Transit Stop and Vehicular Traffic

When a PMR travels on a cycle lane located between a Transit Stop, it shall follow the procedure AuxiliaryTransitStopRoadside defined as follows:

- The PMR must position itself [on the extreme travelSide] and stop at  $5 * \text{shyDistanceStandback}$  before the transit stop when there is a transit vehicle at the transit stop
- The PMR may travel at its normal safe speed otherwise
- See Figure 13



**Figure 12:** Cycleway between transit stop and sidewalk (Source: Human Transit)



**Figure 13:** Cycleway between transit stop and vehicular traffic (Source: NACTO)