

Intelligent transport systems – Public-area mobile robots and similar pathway devices – Part 14: Personal assistant robots for tasks and goods movement

Systemes de transport intelligents — Robots mobiles de l'espace public (PMR) et dispositifs automatisés de cheminement – Partie 14: Robots mobiles de l'espace public Assistant Personnel (PA PMR)

WD

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 204 WG19.

The parts of ISO 4448 are proposed as deliverables, as a foundation for instantiation. Later, additional Standards deliverables may be required for specific applications.

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.

Introduction

This part of the 4448 series addresses personal assistant public-area mobile robots ("PA PMRs"). These are devices that travel beside or behind collaborative or companion humans in order to assist them with non-passenger mobility or a task. They are typically paired via electronic tethering or image-recognition track-and-tether to a human.

PA PMRs includes follow-me devices for luggage or shopping, personal robotic helpers, such as a robotic guide dog or service dog, work helpers, such as robots that carry tools, trash, and packages, or a robotic assistant tethered to a public services officer for fire, police, EMS, or evacuation applications.

PAUSED

Intelligent transport systems – Public-area mobile robots and similar pathway devices – Part 14: Personal assistant robots for tasks and goods movement

1 Scope

This document characterizes and provides recommendations, rules, and procedural guidelines for the deployment of personal assistant public-area mobile robots ("PA PMRs").

In scope are robotic devices that *follow or accompany* a person such as a worker, a traveler, a shopper, and to carry tools, refuse, belongings, goods, etc., or follow a person as a helper, for example as a first-responder, as a police assistant, or as a device to guide a blind person or protect an elderly or frail person.

Out of scope are devices that *carry* humans such as personal health assistant robots, automated wheelchairs that carry patients in a medical environment or travellers in an airport, mobile emergency helper robots that are teleoperated in fire, police, EMS, or evacuation applications carrying human passengers, and collaborative robots operating in non-public (non-pedestrianized) circumstances such as in a factory or warehouse. For these devices, see 4448-15.

2 Normative references

There are no normative references in this document.

ISO DTR 4448-7

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO/TS 14812:2022 and the following terms and definitions 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

Abandoned

a state when a PA PMR has not been **Deactivated** and has been outside the **Activation Radius** longer than the **Abandonment Period**.

3.2

Abandonment Period

a period of time set by the operating authority after which an active PA PMR can be considered **Abandoned**.

3.3

Activation Radius

the distance from the **Companion** in which the PA PMR will remain active.

3.4

Bystanders

nearby humans, such as pedestrians or other active transportation participants, within the immediate operating vicinity of the PMR. Bystanders are not involved in the use or operation of the PMR.

3.5

C-Class Public-area Mobile Robot (C-Class PMR)

a PMR designed to primarily operate on cycleways.

3.6

Companion

a human operator that travels in close proximity to one or more **A-PC PMRs** in order to ensure passenger safety, comprehension, and comfort.

Note to entry: safety, comprehension, and comfort address any form of disability whether it's visual, auditory, cognitive, or age-related.

3.7

Deactivated

a state in which the "follow me" behaviour of a PA PMR has been turned off.

Note to entry: There are two ways a PA PMR may be Deactivated: [1] Stop follow-me mode (but proceed with another activity) and [2] power off (sleep or shutdown)

3.8

Fleet Operator

an entity responsible for the operation a fleet of PMRs.

Note to entry: this includes responsibility for all of the individual robots within a fleet, their trip planning, mechanical and power condition, task deployment, connectivity and responsiveness to a regional **Orchestration Manager** (if any), and human teleoperation or oversight.

Note to entry: this responsibility includes obtaining insurance, licenses, and certifications, as well as a rule following, and responsiveness to enforcement, teleoperator training, and crash clean-up.

3.9

Manual Mode

a PA PMR mode where the PMR's follow-me mode is **Deactivated** but the PMR can be moved manually.

3.10

Macro Plan

a trip plan that extends from the immediate location of a PMR until the end location of the trip being planned or in progress; plan for an entire trip.

3.11

P-Class Public-area Mobile Robot (P-Class PMR)

a PMR designed to primarily operate on pedestrian pathways (footways).

3.12

Personal Assistant Public-area mobile robot (PA PMR)

a Public-area mobile robot that travels with a **Companion** in order to assist them

3.13

Privacy Mode

a mode where a PMR is still operational but not recording visual data.

3.14

Response Time

the time period it takes for PA PMR to match a change in the navigational motion of its **Companion**.

Note to entry: this is the sum of recognition (reaction) time and the time required to alter its motion to match Companion's motion.

3.15

shyDistance

the minimum distance to be maintained between a PMR and a stationary object.

Note to entry: if a PMR cannot determine whether an object is stationary, then it shall use *shyDistanceDynamic*

3.16

shyDistanceDynamic

the minimum distance to be maintained between a PMR and a non-stationary object.

3.17

tetherRadius

the distance from the **Companion** that the PA PMR will target while travelling with the Companion.

4 Characteristics

A PA PMR's dimensions and capabilities shall be governed according to the type of infrastructure they are operating in.

1. A PA PMR operating on pedestrian footways shall follow the behavioural rules set out for **P-Class PMRs** (see 4448-7).
2. A PA PMR operating on cycleways shall follow the behavioural rules set out for **C-Class PMRs** (see 4448-7).
3. A PA PMR shall be guided by the implicit macro-planning from its **Companion** and the meso- and micro path-planning capability within its sensor and software systems (see 4448-6).

In addition to braking within certain *shyDistance* measures, a PA PMR shall comply with the travel trajectory of its Companion in a responsive manner. A PA PMR shall accelerate and turn ("shadowing") in response to Companion's motion so that it remains within the *tetherRadius* while maintaining a sufficient stopping distance (*shyDistanceDynamic*) from its Companion (see Figure 1).

4.1 PA PMR Parameters

Table 1 describes parameters relevant for PA PMRs. *Braking Distance* for P-Class PMRs is specified in 4448-16 and *shyDistanceDynamic* is specified in 4448-2. *shyDistanceDynamic* and *tetherRadius* are defined in terms of ShyDistance Units (SDUs) that are defined in 4448-2 and set by the governing jurisdiction.

Table 1: Several distance parameters for PA PMRs. The use of these parameters is illustrated in detail in **Clause 6**

Capability	Default	Tolerance	Comments
<i>activationRadius</i>	50 m	5 m	<i>activationRadius</i> should be sufficient so that the PA PMR will remain active if both Companion and PA PMR end up on opposite sides of a road. See 6.3 (2.)

<i>brakingDistance</i> (<i>footway</i>)	1000 mm	200 mm	Acts as the minimum distance between the Companion and PA PMR when the Companion is in motion (see 4448-16)
<i>responseTime</i>	600 ms	400 ms	<i>responseTime</i> depends on <i>accessFootMaxSpeed</i> , <i>shyDistanceDynamic</i> and <i>tetherRadius</i> . For the PA PMR to remain within the <i>tetherRadius</i> , the <i>responseTime</i> must be at a minimum: $(tetherRadius - brakingDistance) / (accessFootMaxSpeed)$
<i>shyDistanceDynamic</i>	3 SDU	1 SDU	Acts as the minimum distance between the Companion and PA PMR when the Companion is at rest
<i>tetherRadius</i>	6 SDU	1 SDU	<i>shyDistance</i> units are defined in 4448-2

4.2 PA PMR Types

PA PMRs can be used for several different purposes. These include:

- Follow-me luggage
- Follow-me shopping cart
- Follow-me work assistant (carrying work objects, supplies, or trash)
- Follow-me assistant for public service officer tasks
- Service dog robot guiding a human

While all PA PMRs will share many characteristics and operational parameters, these may vary for specific use cases. For example, service dog robots may need to travel alongside or somewhat in the lead of their **Companion** instead of trailing.

5 Considerations

5.1 Rules Hierarchy

With few exceptions, a PA PMR shall not proceed without its **Companion** since it is designed to acquire its Macro Plan by following that Companion.

In the event that a PA PMR's Companion does not obey the applicable rules of the road, such as when a Companion crosses a road illegally, or with too little time to clear a designated road crossing area, or adopts a speed in excess of the allowed speed for PMRs in a given context:

- the PA PMR shall adopt a safe state
- the PA PMR shall follow the rules of the road even if it becomes separated from the Companion
- the PA PMR shall use a sound and light display to indicate that it cannot follow the Companion's lead because a rule is being broken
- providers of PA PMRs shall ensure that Companions understand these PA PMR behaviours

A service-dog PA PMR or other follow-me assistant performing a medical or disability-related task shall not proceed without its Companion.

5.2 Travel in Crowded Spaces

Crowded spaces may present a challenge for the use of PA PMRs. There must be enough space within the {Companion, PA PMR} pair so that the PA PMR does not collide with the **Companion**, and the space must be small enough to discourage other pedestrians from passing between or staging themselves within the {Companion, PA PMR} pair.

In crowded spaces, the distance within the {Companion, PA PMR} pair shall be reduced to a maximum of *shyDistanceDynamic*. (Figure 1)

Since the nature of a crowded, human/pedestrian space is culturally and contextually dependent, it is not feasible to provide a formal, measurable description for what crowded means. Hence, one of two methods shall be adopted by {Companion, PA PMR} pairs:

1. The Companion shall determine whether they are in a crowded space, and shall cause an appropriate reduction in their combined operating space by moving closer to the PA PMR or by drawing the PA PMR closer, or
2. The PA PMR shall determine whether they are in a crowded state and draw suitably closer to the Companion. In the case that the PA PMR is gauging this distance, its path planning system shall minimize this distance while ensuring no collisions. In the event that the PA PMR is unwilling to adjust its *shyDistanceDynamic* effectively in a crowded environment the Companion shall take manual control or move to a less crowded pathway.

This paragraph anticipates that in some crowded spaces a Companion and PA PMR may touch (*shyDistanceDynamic* forced to zero). An example would be a service dog PA PMR on a public transport vehicle. In such cases, the Companion shall be responsible to close this gap.

5.3 Travel positioning relative to Companion

{Companion, PA PMR} pairs shall travel in a manner that minimizes the disruption to other pathway users. In most cases, this will mean travelling behind its **Companion**. However, there may be cases where a PA PMR must travel alongside or in front of its Companion. An example would be a service dog PA PMR serving a blind Companion. Such a PA PMRs shall be permitted travel alongside or slightly in front of its Companion.

Note: It is possible that a Companion using a personal follow me device such as luggage or a shopping aide might be made uncomfortable by not being able to readily see their PA PMR, if it is following behind. Hence, allowance may be made for the PA PMR to travel beside its Companion. This may constrain the pathways in which such devices may be used. This may be addressed by requiring additional manoeuvring on the part of the {Companion, PA PMR} pair when passing **Bystanders**. Bystanders shall not be inconvenienced, alarmed, or made uncomfortable by the combined behaviour of a {Companion, PA PMR} pair.

5.4 Indoor Travel

Indoor travel may be slower and more space-constrained than outdoor travel. In these circumstances, PA PMRs shall behave in a similar manner as in a crowded space. The distance between the **Companion** and PA PMR shall be reduced, where appropriate to *shyDistanceDynamic* (Figure 1), and in some cases possibly zero (see clause 5.2).

5.5 Privacy

There may be situations where a PA PMR enters a privacy-sensitive environment such as a public washroom. Examples include a service dog PA PMR guiding its blind **Companion** within a washroom or

a traveller bringing follow-me luggage into a washroom, a police station, a hospital or other recording-restricted place.

For PA PMRs to enter a space where personal privacy is a concern, the Companion shall engage either:

1. **Manual Mode:** a state in which a PA PMR shall not record image or audio but PA PMR motion remains possible (non-braked), allowing its Companion to guide and move the PMR manually. In Manual Mode, a PA PMR is no longer capturing visual or auditory data, hence cannot path-plan (e.g., this is appropriate for follow-me luggage).
2. **Privacy Mode:** a state in which a PA PMR is both self-propelled and continuing to path-plan but is no longer retaining visual or auditory data beyond the immediate need for path-planning (seconds). Privacy Mode is required for service dog PMRs so they are able to assist their Companions in all feasible circumstances, while being prevented from retaining or transmitting data beyond the time needed to assist the Companion (likely a few seconds).

6 Procedures

6.1 Travel, linear

A PA PMR shall travel directly behind or in front of their **Companion** as much as possible at a maximum speed of *accessFootMaxSpeed*. This is to conserve pathway width for other users.

A PA PMR shall travel at a maximum distance of *tetherRadius* removed from the Companion. This is to minimize the probability of separation of the {Companion, PA PMR} pair possibly caused by unintended events such as intervening **Bystanders** or intersection-control timing when crossing a roadway.

A PA PMR shall travel at a minimum distance of *brakingDistanceFootway* removed from the Companion. This is to minimize the probability of a collision between the pair as might occur if the Companion were to suddenly stop or change course.

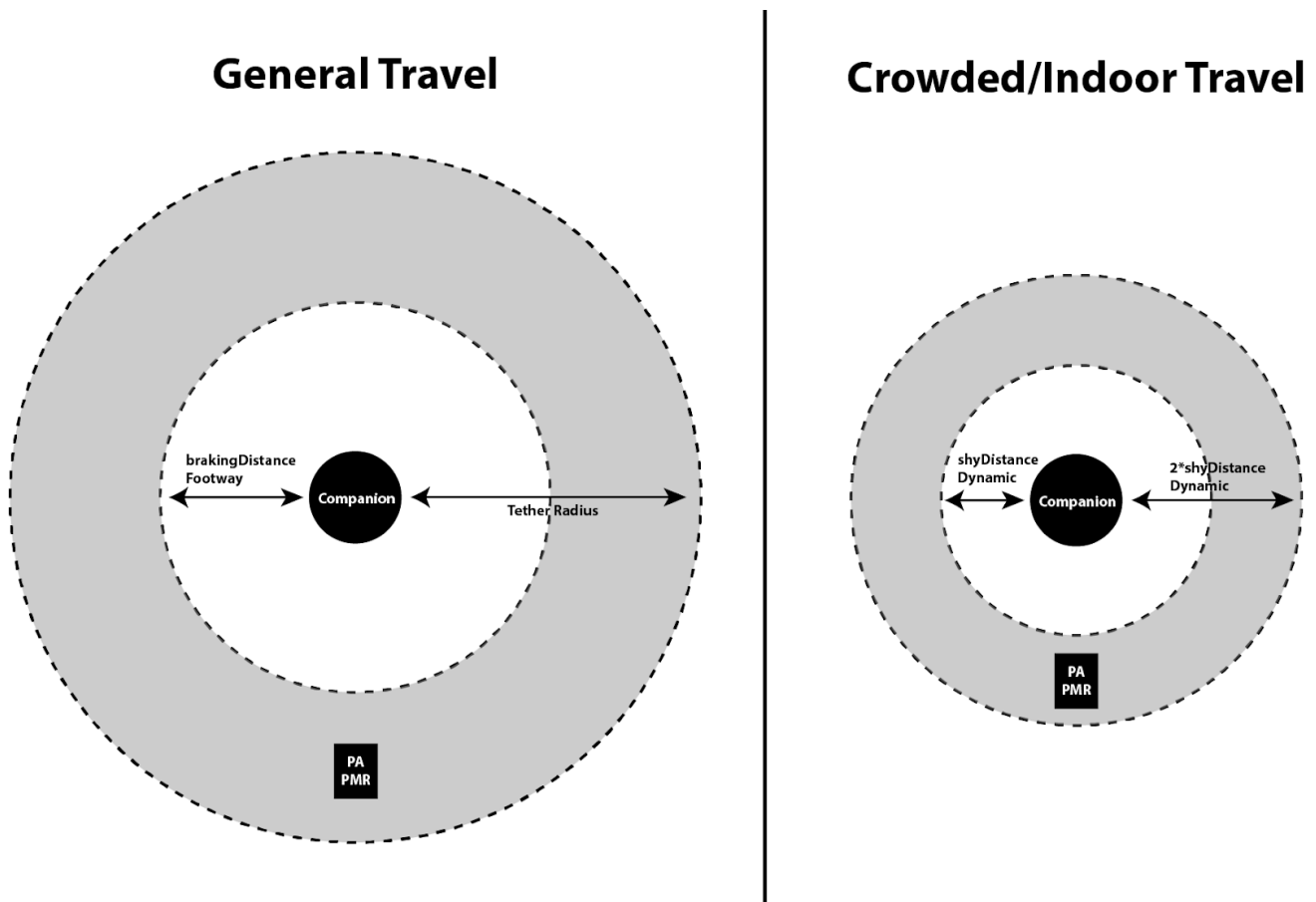


Figure 1: Travel separation distances for PA PMRs

6.2 Travel, side-by-side

For PA PMRs that travel alongside their Companion, they shall travel at a matching speed (up to `accessFootMaxSpeed`) at a preferred distance between `brakingDistanceFootway` and `shyDistanceDynamic` and a maximum distance of $2 * shyDistanceDynamic$.

6.3 Travel At Road Crossings

A PA PMR shall obey pedestrian rules at road crossings. There are two methods to comply with this requirement.

1. The **Companion** shall always follow local pedestrian rules. The Companion shall be responsible, and the PA PMR shall follow the Companion's path-planning lead. In this case, the PA PMR is not required to understand pedestrian rules as it implicitly obeys the Companion's interpretation of those rules.
2. The PA PMR is sufficiently enabled to follow pedestrian rules and is enabled to override implied navigation directions from the Companion. An example of this is a case in which a {Companion, PA PMR} pair is at a road crossing and the Companion proceeds to cross with insufficient time to complete the crossing at the permitted operating speed of the PA PMR. In this case, the PA PMR shall halt and withdraw from the departure area (e.g., kerb or ramp) of the crossing, and shall perform the procedure ***PathwayWaitShort*** defined in 4448-7 at an area of the sidewalk nearest to the kerb that is free of pedestrians and outside of the **Pedestrian Through Zone**.

This second method assumes that the PA PMR has sufficient capability to define its own path planning, and be capable of determining an appropriate place to wait. Very few follow-me robots are likely to be capable of this and fewer still will have a backup teleoperator to intervene. This further implies that the

first of these two methods is most likely the appropriate method to use. This second method is included here for completeness.

6.4 Travel, Crowded or Indoor

In crowded or indoor spaces, the {Companion, PA PMR} pair shall travel at a maximum speed of *accessFootMaxSpeed*. They shall travel at a mutual distance between the *shyDistanceDynamic* and *tetherRadius*.

Companion speed in a crowded/indoor environment shall be such that the then-applicable *shyDistanceDynamic* is always greater than *breakingDistanceFootway* (see Figure 1). Hence the currently-relevant *shyDistanceDynamic* shall be computed continuously.

6.5 Travel, Short Rejoin

It may happen that a PA PMR becomes separated from its Companion (i.e. the distance between the two exceeds *tetherRadius*). In this case, the PA PMR shall perform the procedure ***AssistantShortRejoin*** defined as follows:

- The PA PMR shall signal that is attempting to rejoin the Companion
- The PA PMR shall obey all traffic rules
- The PA PMR shall travel at a max speed of *accessFootMaxSpeed*
- The PA PMR shall maintain appropriate *shyDistances* from other users and objects

Failing this, see 6.6 Travel, Long Rejoin.

6.6 Travel, Long Rejoin

If a PA PMR becomes separated from its **Companion** by a distance greater than the *activationRadius*, the PMR shall employ the procedure ***PathwayWaitLong*** defined in 4448-7.

If the Companion summons the PA PMR, the robot shall employ procedures ***PathwayStarting*** and ***PathwayTravelDefault*** defined in 4448-7. This shall not require a Trip Plan.

6.7 Self-Deactivation

If a PA PMR remains outside the *activationRadius* and has not been deactivated by the **Companion** or a **Fleet Operator**, and the **Abandonment Period** has elapsed, then it shall be considered **Abandoned**.

The remainder of this procedure is out of scope. At this point, the PA PMR may send a distress message to a prearranged emergency operator and then self-deactivate follow-me mode.

6.8 Emergency tasks

There will be emergency PA PMRs used in exceptional or emergency situations, especially for police, fire, EMS and evacuation services. These may require exceptions to these PA PMR standards. Such exceptions shall be locally determined and are out of scope for 4448.

Nonetheless, the following guidelines are explicit:

1. Any operational requirement from a fire, police, EMS, or evacuation perspective during the execution of any duty-related public service action may override any PA PMR 4448-14 guidance.
2. A {Companion, PA PMR} pair within a pedestrianized space and not attending at an emergency circumstance, shall follow all PA PMR guidance to be compliant.

3. It shall be enabled for a trained Companion to command an emergency PA PMR to exceed any speed, distance, time or other metric when the PA PMR in question is working in an emergency capacity, i.e., when an emergency {Companion, PA PMR} pair is moving within an active emergency scene (fire, arrest, medical emergency, evacuation, etc).
4. An emergency PA PMR shall have simple, unambiguous, unmistakable, override method(s) under Companion control to switch into and out of normal PMR standards-compliance mode. Such method(s), may be any one or more of control switch, electromechanical interface, voice command, radio command, or AI-mediated PMR autonomous decision
 - The override method(s) deployed shall be protected from accidental or cyber-attack activation or deactivation
 - Such override method(s) and the organizational rules that govern them are out of scope for this standard.
5. The provider (vendor, manufacturer, maker, coder, trainer, or fleet manager) of an emergency PA PMR shall provide a training method such that any Companion may be certified to understand and be able to execute these special methods and commands.
6. A PA PMR that is entering an emergency scene, as determined by its Companion, shall display locally-determined emergency scene lights, and the Companion shall inform any **Bystanders** to keep the emergency-scene distance normal to the jurisdiction of operation.
7. If a {Companion, PA PMR} pair is not within a pedestrianized space, or if Bystanders are excluded from their current operating space, 4448-14 compliance may be ignored.

[end current working draft — 2023 09 23 — PAUSED]

7 Bibliography

Li, Ruowei (2022) "Simulating Behaviour of a Person-following Delivery Robot in Pedestrian Environments."