ISO 4448-20:2023(X)

ISO TC 204/WG 19

Secretariat: SCC

Intelligent transport systems —Public Mobile Robots (PMR) and similar pathway devices — Part 20: Journey data recorder for non-occupant elements

Key: Tracts that need work
Matters that are unsettled
Notes from stakeholders under resolution

To: URF Members:

On this round (March 21-23, 2023) the project team asks:

1. Have all necessary efficient elements been included (i.e., anything missing?)
2. Is the draft solution for each of these elements in the best/appropriate direction?
3. Is anything confusing, or ambiguous?

Remember:

1. This part (-20) sits in a much broader context that deals with behavior, orchestration, social and environmental (ODD) constraints and more.
2. The data dictionary is in 4448-2
3. 4448-16 “Safety and Reliability” and 4448-8 “R2H communication” are predecessors and critical companions to -20, are both still WD only

Please note:

The scope of this document is still **undecided**.

Some elements are reminiscent of automotive crash data recorders that involve subsystems that address human occupant safety.

It is proposed that the scope of this document exclude **human-occupant** safety subsystems.

Note the discussion in the Scope.

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The PROXIMITY RECORD 6.6 is our major focus, on this first draft.

WD/CD/DIS/FDIS stage

Contents

Foreword

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This document was prepared by Technical Committee *[or Project Committee]* ISO/TC *[or ISO/PC]* 204 [intelligent Transport systems] *Working Group 19[mobility Integration]*

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

The purpose of the ISO 4448 series is to define the data and communication systems needed to organize and expedite the flow of automated ground traffic devices in public spaces. This includes the loading and unloading of robotic passenger and goods vehicles at the kerb as well as ***public mobile robots*** or **PMR**s engaged in construction, food carts, inspection, garbage removal, last-mile delivery, mopping, parking management, repair, snow removal, surveillance, sweeping, washing and any other robotic service conducted on sidewalks (pavements), cycle paths, crosswalks or other public, pedestrianized space inside or outside of buildings. PMRs are inclusive of automated wheelchairs, trolleys, return-to-base micromobility devices, and ‘follow-me’ devices, etc. A full definition for PMRs can be found in ISO 4448-2.

The term *public mobile robot* is used in distinction from *industrial mobile robot* in that PMRs are expected to operate in proximity to humans that are untrained and not involved in the tasks of said PMR. Parts 1-19 of ISO 4448 specify different aspects of these devices.

PMRs travel on pedestrian footways, cycle lanes, building passageways, etc. (as permitted by local regulations) to reach their destination, and may have to cross roadways, and sometimes travel on roadways and road shoulders. There they may encounter persons, animals, wheeled devices propelled by humans, other PMRs (who may be travelling to a destination, or performing a task such as snow clearing or street cleaning), etc. PMRs may also be moving in other public, pedestrianized spaces, such as airports, hospitals, hotels and shopping malls. The ISO 4448 series specifies how they do this and interact with those they encounter.

However, there will be situations where crashes (whether caused by the PMR or inflicted on it) occur or complaint may be made against its behaviour. ISO 4448-16 therefore specifies that a PMR shall be fitted with a ‘journey data recorder’ (JDR) to enable authorised parties to obtain access to relevant data so that such incidents can be described, investigated, remedied and understood in the event of apportioning liability in an insurance claim.

ISO 4448-20, specifies this Journey Data Recorder. Its provisions concern the minimum data collected and stored and the crash survivability of journey data collected by a PMR and stored in its JDR. It does not include specifications for data retrieval tools and methods (as these may be subject to national/regional level requirements).

The purpose of these provisions is to ensure that a JDR records, in a recoverable manner, data valuable for effective incident investigation and for understanding whether a PMR was or is exhibiting expected behaviours. These data will help provide a better understanding of the circumstances in which crashes, injuries, or other incidents occur and will facilitate the development of safer PMR designs and better understanding in the event of insurance claims.

Intelligent transport systems —Public Mobile Robots (PMR) and similar pathway devices — Part 20: Journey data recorder for non-occupant elements

1 Scope

The scope of the 4448-20 specification provides requirements for automated mobility devices on non-industrial pathways known as *public mobile robots* (PMRs) and similarly controlled devices that use pathways in public, pedestrianized places with regard to requirements for and capabilities of a Journey Data Recorder (JDR).

Note: This Specification is without prejudice to requirements of national or regional laws related to privacy, data protection and personal data processing.

@bern proposes that the scope/purpose of 4448–20 be constrained to journey and crash data and behaviours that relate to PMR mobility involving its impingement on the environment and bystanders, and the impingement of the environment and bystanders on the PMR.

Because there are numerous standards in place for recording crash-related matters of machine components that protect human occupants (such as seatbelt conditions), it makes most sense for those subsystems (and the capture of information about them during a crash) to be out of scope for this document, even though a 4448-20 compliant journey data recorder may be extended to include those.

Specifically, I am proposing that 4448-20 define the data subsets for a *JDR specific to the non-human occupant matters*. (The great majority of the application of PMR's are for non-human transportation.) Additional elements related specifically to human safety systems can either be adapted from existing standards, as the first draft of this document attempted to do, or can later be defined and added, as a **separate part of 4448.**

It is important to settle this issue shortly. Standards impacting human occupants, human constraints, etc. invite for more scrutiny, then standards, impacting the interface between devices and environment or devices and bystanders.

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.

ISO/IEC 8825-1:2021: *Information technology — ASN.1 encoding rules — Part 1: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER)*

ISO DTR 4448-1: *Overview of Public mobile robots (PMRs)*

ISO DTS 4448-2: *Data Definitions for Public mobile robots (PMRs)*

ISO DTS 4448-16: *Safety and reliability of Public mobile robots (PMRs)*

EN ISO 13482:2014: *Robots and robotic devices—Safety requirements for personal care robots.*

IEEE 7001: 2021: *Transparency of Autonomous Systems*

~~**NIST SP 1011-II-1.0:** *Autonomy Levels for Unmanned Systems (ALFUS) Framework*~~

UNECE Working Party 29 *Addendum 159 – UN Regulation No. 160. Uniform provisions concerning the approval of motor vehicles with regard to the Event Data Recorder*

Informative references (where does this go?)

The following documents influence the direction and requirements of this document.

Salvini, P., Paez-Granados, D., Billard, A. (2021) - *On the Safety of Mobile Robots Serving in Public Spaces: Identifying gaps in EN ISO 13482:2014 and calling for a new standard*

Salvini et al provides an extensive list of criticisms of 13482:2014, many of which are addressed in various parts of 4448. We believe that 4448 should address the majority of those criticisms that happen to apply to mobile robots, and we assert this has largely been accomplished in the current 4448 Part drafts and outlines. There are several other criticisms that apply to robots that may engage in physical contact with humans, but that is out of scope for 4448. This will be discussed fully inTR4448-1.

Winfield AF, van Maris, A., Salvini, P., and Marina Jirotka, M. (2022) *An Ethical Black Box for Social Robots: a draft Open Standard*

Winfield et al provides a draft list of elements for a "ethical black box recorder", and we are using some of that in the draft of 4448–20.

3 Terms and definitions *(all terms moved to 4448-2)*

@lee, Many/most of the terms originally proposed have been inherited from UNECE W29 Regulation 160. We need to decide which we'll be using/keeping (not all of them) before we include them in 4448–2; wait until after March 2023.

No terms and definitions are listed in this document.

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/

4 Abbreviations and Glossary

Type text.

(ANFUS and NIST appeared only in an Informative section. Better that be moved to TR 4448-1)

5 General requirements

5.1 JDR

This specification adopts the term 'Journey Data Recorder' (JDR).

NOTE: in order to distinguish it from the similar but different 'Event Data Recorder' (EDR) requirements for road vehicles and 'Flight Data Recorder' (FDR) for aircraft)

The detailed design of such a journey data recorder is outside the scope of this standard, but the minimum form and output of data from such a device is specified herein. Manufacturers may provide additional data, and in this event are recommended to provide an interpretation of that additional data to authorised parties.

5.2 JDR Data and data retrieval

The data elements and format stored in the JDR; shall be provided as defined herein.

Instructions for retrieving data from the JDR; shall be provided.

5.3 JDR location, triggering, storage and resistance

A description of the PMR type with regard to the items specified in Annex D?, in particular related to the location of the JDR in the PMR, the triggering parameters, storing capacity and the resistance to high deceleration and mechanical stress of a severe impact; shall be provided.

5.4 JDR failure

The case of the JDR not being operational at the time of an incident is a failure, this failure state shall be recorded by the JDR [how is this possible is the JDR is not operational?] (as defined in the data elements Annex A. Data elements.)

Agree, not seeing how this would work. You could have some kind of passive accelerometer that 'breaks' when a certain acceleration has been reached, indication that a collision has taken place. That or, it has been determined manually that the JDR was not on at the time of the incident.

You could also require PMRs to be immobile if the JDR is not engaged or not recording.

5.5 Public mobile robots ("PMRs")

PMRs are a class of automated devices that include a wide range of form factors to address a wide and diverse catalogue of tasks including loading and unloading of goods at the kerb, and the allocation and movement of service vehicles for inspection, garbage removal, sweeping, mopping, snow removal, repair, food trucks, construction, surveillance, etc. PMRs not only include devices that are obviously identifiable as robots, but also include other devices (such as automated wheelchairs, automated trolleys, automated return-to-base micromobility devices, automated 'follow-me' devices, etc.) that have automated functionality in the same physical domain of operation. (Full definition of PMR is to be found in ISO 4448-2).

The term *public mobile robots* is used in distinction from *industrial mobile robots*, and parts 1-19 of ISO 4448 specify different aspects of these PMRs.

The common physical domain of operation that all instances of PMRs share and travel on are pedestrian footways, cycle lanes etc. (as permitted by local regulations) and other public zones and accessways to reach their destination, and may have to cross roadways, and any other service conducted on sidewalks (pavements), cycle paths, crosswalks or any other public, pedestrianized space including both indoors and outdoors.

The requirements for a journey data recorder in respect of triggering, recording and storing data, will largely be common, but various categories of PMR will have additional triggering and data storage requirements (for example automated wheelchairs, automated trolleys that are, or may be, conveying people). The common data requirements are to be found in Annex A, and the additional features and data for specialised use cases are to be found in Annex B

5.6 PMR Transparency

The provision of a JDR in a PMR is a means to address two critical transparency requirements of IEEE 7001-2021 “Standard for ‘Transparency of Autonomous Systems.’

1. This standard part satisfies Level 3 “Transparency requirements for *incident investigators*” outlined in Table 4, specifically, “Autonomous systems shall be equipped with [a data recorder]…capable of recording a time stamped log of key system inputs, outputs and high-level decisions.”
2. This standard part enables up to Level 4 “Transparency requirements for *expert advisors* in administrative actions or litigation” outlined in Table 5. Specifically, “…there shall be a full audit trail for all of the quality, risk assessment and control/mitigation, ~~[and ethical governance processes]~~ in Levels 1–3 above. This audit trail may, for instance, form part of evidence within legal proceedings, internal investigations~~, [or a public inquiry]~~.

IEEE 7001-2021 transparency objectives go far beyond the JDR specification of 4448-20. Nonetheless, for the case of PMRs, the JDR is an essential component of achieving partial compliance with IEEE 7001-2021.

This is because automated systems, such as PMRs work with or alongside humans who need to be able to understand what the systems are doing and, in some instances, why. Transparency is important in adjusting expectations and, hence, building confidence, and part of that confidence is derived from the availability of data from a JDR.

Any system, including an automated system such as a PMR, can fail. If a PMR fails it has the capacity to cause harm or injury. Failure may be due to its software, its operational behaviour, or a cause external to the PMR such that it must take action to avoid damage to humans, and possibly to itself, or in the event of a crash, to minimise damage to humans and to itself. The JDR provides data to enable evaluation of whether it has done so correctly, and in many cases to establish the cause of the incident (“event”). Additionally, establishing how and why a system made a correct decision is important for the processes of verification and validation.

In the absence of such transparency, public confidence, accountability, and the attribution of responsibility can be difficult. Public confidence which is required to allow PMRs to be permitted to be used in public spaces and on pathways shared with pedestrians, cyclist, and other active mobility users, as well as roadway vehicles at the crosswalk, curb and shoulder. It might also be important to establish who is responsible for insurance or regulatory purposes or in an administrative proceeding or court of law. The evidence from a JDR can help assign accountability and responsibility. Society can benefit from the reassurance of knowing that PMR faults have been found and addressed.

The JDR handles data logging to provide investigators with time stamped records of what a PMR was doing or experiencing prior to and during an incident, near-miss or other incident that may have triggered bystander complaints.

NOTE: IEEE 7001 specifies that transparency should be designed into the system; ideally from its inception rather than retroactively. *'The quality of transparency does not manifest without careful consideration and adherence to best practices and rigorous standards.'*

In order that a JDR supports comprehension by stakeholders, the data it captures must be necessary and sufficient and provided in a consistent and accessible format. The provisions of Clause 6, and other provisions in this specification provide that consistency.

The principle behind this standard for PMR JDRs is that it should always be possible to understand why and how (e.g., by what decision-making logic, algorithm, or prediction mechanism) a PMR behaved in a particular way.

Such information shall be accurate, contain information relevant to the causes of its actions, decisions, or behaviours, and be presented at a level of abstraction and in a form that is consistent, unambiguous and interpretable.

~~5.7 System autonomy~~ (redundant; be sure this is covered in 4448-1)

~~A PMR, while typically classified as 'automated' in that it is making at least some dynamic decisions on the basis of its instruction set and dynamic data presented to it, may have different levels of autonomy. It may or may not be under the direct control of a human operator. In some circumstances it may operate autonomously for some actions, but will always be under the supervisory control of a human operator or computerised management system, or a combination of these to achieve control. For the purpose of this standard, a PMR is understood to be a system that has the capacity to make decisions itself in response to some input data or stimulus with a varying degree of human intervention, depending on the system's level of autonomy.~~

~~System autonomy falls on a spectrum from zero to full autonomy, where zero means the system is entirely under human control and full autonomy means the system can accomplish a goal without human guidance or intervention.~~

~~NIST introduced the Autonomy Levels for Unmanned Systems (ALFUS) as a nomenclature consisting of four levels of autonomy, namely, remote controlled, teleoperated, semi-autonomous, and fully autonomous (see NIST SP 1011-II-1.0).~~

~~Based on ALFUS nomenclature, Durst and Gray [B2] expanded these four levels as follows:~~

~~*Human Operated:* A human operator makes all decisions.~~

~~*Human Delegated:* The system can perform many functions independently of human control when delegated to do so.~~

~~*Human Supervised:* The system can perform a wide variety of activities when given top-level permission or direction by a human.~~

~~*Fully Autonomous:* The system receives goals from humans and translates them into tasks to be performed without human interaction.~~

~~IEEE 7001 – 2021 describes three components of supervised automation, as:~~

- ~~Direction, i.e., telling a system what to do~~
- ~~Monitoring, i.e., watching what the system is doing~~
- ~~Control, i.e., being able to intervene and change what the system is doing~~

5.8 Source Code (out of scope for 4448-20)

Authorised parties will require access to the source code *(this may not be effective in the case of some development paradigms)* of the system in an unambiguous and consistent manner. For this reason, the format of the data representation is specified in ASN.1. (ISO/IEC 8825-1:2021). See Clause 6.7.1?, and see Annex C for an example of a suitable ASN.1 module.

5.9 Incident investigation

Following an incident ('event'), it shall be possible to trace the internal processes of a PMR that, over some time (define this[1]) period, led to the incident. This subclause requires that a system be equipped with a JDR logging system for data, capable of securely recording a time-stamped log of key system inputs, outputs, and (ideally) high level decisions (as specified in Clause 6 and its associated Annexes).

5.10 JDR capability and protection

PMRs shall be equipped with a JDR capable of securely recording a time stamped log of key system inputs and outputs, as specified in Clause 6 below. The function of the JDR is to continuously record the most recent *n* minutes or hours of relevant time-stamped data, including sensor data and actuator demands (as appropriate for the system in question). (This needs a table.[2])

The external data recorded by such a device shall be relevant to the purpose and operation of the PMR.

JDR data shall be securely stored in a standard format.

Where permitted by law a JDR shall have appropriate and sufficient video and audio input to allow playback of the situation around the PMR at the time of an incident.

Because of the variability in acceptability of retaining recorded image data from the ODDs anticipated, WG19 needs to establish a common denominator of what can be captured, how long it can be retained, and under what circumstances retention can be extended. As much as possible, we would seek this to be maximally consistent across jurisdictions, and we would also seek to have this least common denominator satisfy the quest for transparency as defined in Clause 5.6.[3]

The JDR shall be able to operate independently of the remaining elements of the PMR. This means that the *recording and storage device* must be able to record unmodified, correctly time-stamped, and non-modifiable data through a means that is not dependent on the PMR, except for charging a battery on the JDR that provides a source of power independent from the non-JDR elements of the PMR.

The input sensors that capture data for the JDR shall either be the same input sensors that the PMR uses for its decisions, or shall be able to provably provide the identical data stream as those input sensors. The reason for this is that on event reconstruction, incident investigators and expert advisors must be certain

[1] This could be tricky. If the incident is the result purely of motion, we could have a maximum of the journey time. However, if a mechanical system played a role, the pattern may only be visible over several journeys. (That said, such a problem may only be important for the fleet operator and manufacturer and not the regulator). This needs much more thought. For PMRs at 6kph, we intend to capture significant crash, near-miss, and vandalism data with the Proximity Record. Machine and component failure were not part of this. **This matter needs review.**

[2] Why not just have the same recorded duration for all systems? Wouldn't different times just overcomplicate things?

[3] Create definitions for types of image data that could be recorded (e.g. identifiable image data, non-identifiable image data, object-only image data, etc.) This would be easy to describe, but daunting to execute.

that the data the PMR used for making decisions is the same data fed to the PMR to be used for event reconstruction.

The sensors feeding the JDR (e.g., camera, accelerometer, etc.) shall be mounted to best capture data that it is required and able to capture and retain.

The processing, recording and storage unit (the JDR) must be mounted and protected for maximum survivability of crash, fire, spill, and vandalism.

To the extent possible, the JDR shall continue to process, record and store after an incident, but shall not overwrite incident-relevant data (Clause 6.9.7)

5.11 Discussion of Robots in Scope

Mobile and/or social robot devices are being deployed or will be deployed in nearly every area of human activity. In doing so, they will effectively have an infinite variety of interactions with humans. Those interactions range from the sterile user interface of setting up a house vacuum and being aware not to trip on it to the complex social interactions embodied in emerging, humanoid, large language model robots that will be social companions for seniors, or co-workers in an office or factory.

A significant portion, possibly the majority, of such robots will be mobile. Mobility may range from the highly constrained, software-mediated mobility of a private home vacuum cleaner to the farther-ranging, multi-kilometre, mobility of a suburban delivery robot.

Robot mobility is managed via a combination of automation and teleoperation. As technology matures, this combination will become increasingly autonomous and teleoperation will gradually contract to oversight, management, recovery and enforcement.

The public attributes of locations in which mobile robots operate will range from the intense privacy of an intimate personal companion to the public role of a tour guide.

The degree of social-psychological interaction between bystanders and robots will range from very little, such as a snowplough operating at night that might only occasionally encounter bystanders, to the warm and gregarious interactions of robot elder companions at game and meal-time in a senior-care home.

In Figure 1, this multi-dimensional space is shown as a combination of the space of public mobile robots for mobility services, maintenance tasks and surveillance activities and the space of social robots serving social and human relation activities. These two major categories within this space span a continuum, without a clear boundary between what are considered public mobile robots and what are considered social robots. Every public mobile robot has some aspects of a social robot in that at the very least it shares space with human bystanders or collaborators and must behave appropriately there. For example, a delivery robot may interact socially by signalling its intentions to bystanders it passes and by collaborating with the person who may be extracting a package being delivered. Of course, any highly social robot that is mobile must also be constrained in its movements by the environment and the bystanders that share that environment, hence having at least some properties of a public mobile robot.

Hence, some behavioural aspects of a mobile robot are only about mobility and navigation (for example, the rule about waiting for a walk signal), other behavioural aspects are purely social (such as sending the "gratitude" signal to a bystander or a collaborator, and yet others are a combination such as moving to the right to make room for a passing bystander.

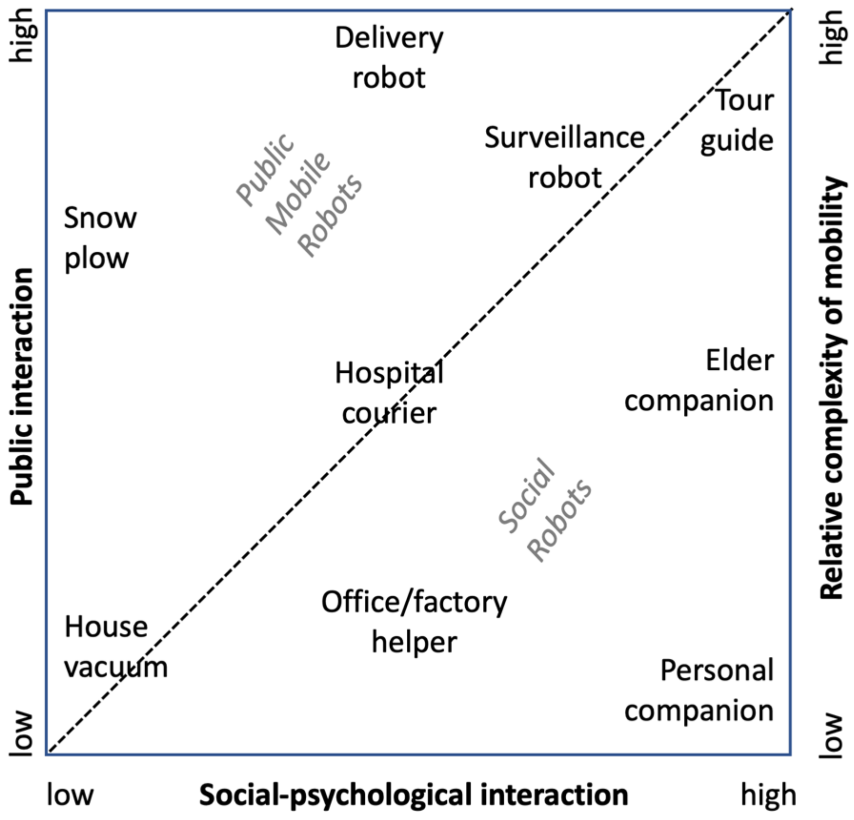

Figure 1: The landscape of mobile and social, human-scaled robots

For these reasons, a journey data recorder that is suitable for every possible robot application in the entire domain of mobile robots that operate in shared public spaces or private social spaces would tend to be complicated, unwieldy, and likely impossible.

Clause 6 of this document, describes JDR data structured in modules so that a designer may elect only those modules appropriate to the task, and so that a certifier may know which aspects to ensure are present and operating. These modules are:

1. Device identification elements that every JDR must have
2. Device operating elements that every JDR must have
3. Device static location elements
4. Device dynamic location elements (position, direction, momentum)
5. Device configuration elements that any tool carrying robot JDR must have
6. Navigation intention elements that every mobile robot JDR must have

The JDRs of higher order social robots must record additional social interaction elements. While this component is out of scope for this draft, the data structure of the JDR can be extended to add additional data modules.

What else is needed? Compare [6] Winfield et al “An Ethical Black Box for Social Robots: a draft Open Standard”

6 Specific requirements

This clause is in very rough outline. The exact lists and detail descriptors for each measurement to be captured are incomplete. It's best to read this draft with the question: "Are we thinking about the right sort of data elements, have we missed any categories, are we considering any that are unnecessary?" In other words — necessary and sufficient.

6.1 Realtime static and dynamic robot journey elements

See the list at the end of 5.11

6.1.1 Device identification elements

Device identification elements are required by every JDR. This tuple must identify a unique physical PMR device beyond any doubt.

robotMake	Make/Manufacturer	Fixed string
robotModel	Model (full string)	Fixed string
robotSerialNum	Unique	Fixed string
robotOSVersionNum	Current installed in this robot	Fixed string
robotOSVersionDate	Time of most recent update to this device	Time-Date string
robotSWVersionNum	Current installed in this robot	Fixed string
robotSWVersionDate	Time of most recent update to this device	Time-Date string
robotName	Optional identifier string, 'nickname"	string

6.1.2 Device operating elements

Device operating elements are required by every JDR. This tuple identifies the current principal operating conditions of the device, including physical dimensions.

Configuration of the PMR holding the JDR.

robotOwnerOperator	Unique identifier of the owner/operator (usually a company) (static)	string
robotTeleoperator	Unique identifier of the human responsible for teleoperation, monitoring, or operational oversight. This is updated every time the operator changes. The operator may be a team member that shares operating duties. (dynamic)	

robotLength		float?
robotWidth		float?
robotHeight		float?
robotWeight		float?

6.1.3 Device static location elements

Device static location elements are required by every JDR. This tuple must identify the location and orientation of a physical PMR.

Accuracy will be given by the appropriately deployed location determination technology.

Precision will be given by the task requirements. For example, a robot that is stopping to allow a human to extract a package from a holding bay may be less precise than a robot that is depositing a package into a micro-locker compartment at the curbside. A mobile humanoid robot that is physically guiding an elderly adult will have to be still more precise yet.

GPS (X,Y,Z)	At the Center of Gravity (CoG) of the robot.	
	Six degrees of freedom around the CoG of the device.	{x,y,z,roll pitch,yaw} with
Device heading	Axis of the device's forward, motion, vector relative to ground	

We need to pick a standard axis system for this. And we have to recognize that this is insufficient for all robots. Any robot that has an arm jointed arm will have 6° of freedom at each joint and there are applications where that will be important in the JDR, so we have to come back to decide how to handle this.

6.1.4 Device dynamic location elements

Device dynamic location elements are required by every JDR. This tuple must identify the changes in location of a physical device.

Accuracy and precision will be given by the design purpose of the device (more work needed here...)

x	x	Fixed string

6.1.5 Device configuration elements for tool carrying robots

Many robots can be fitted with tools. For example, a street sweeper might have a rotating brush, or a delivery robot would have a locked bin in which cargo is secured. These task-related components are "tools."

Some robots can be fitted with several tools, so that the same robot at one point in time might have a tank and nozzle to spray salt on the sidewalk, and at another point in time might be carrying a surveillance camera.

Other robots may be equipped with arms, such that they can reach out to do a task, or place a package on a surface or into a locker. These additional tools change the spatial envelope of the robot. This means that the base robot described in 6.1.2 must be adjusted in realtime for the current configuration of these tools. An example might be a delivery robot with its arms folded neatly within its travel envelope, upon arriving at a delivery location extends its arms to perform a package placement. That extension, when it occurs, changes the size of the robot, and that must be recorded in the JDR.

This can be done in one of two ways. The first is that upon commencement of the tool extension, the robot can record the new total expected size, because the robot has examined the area of operation and has pre-determined there is room for the intended extension without harm or crash. The second way is that the robot can record changes in the size of the envelope on a second-by-second basis.

The first way is far simpler, but risks errors that would be difficult to accurately reconstruct. The second way, of course, is more complicated and more data intensive.

Neither of these approaches are particularly sophisticated for the case of humanoid, ambulatory robots, because both of these approaches are only recording a simple rectangular cuboid.[4] But for many wheeled robots that are roughly rectangular cuboids, the approximation is likely satisfactory.

An example of this in practice is that the travel size of a delivery robot is a specific rectangular cuboid; however, when it is opened for package extraction, that cuboid changes. The lid or door creates an extension of the shape, and any mishap or harm that occurs because of that change is what we wish understand by capturing that shape change in the JDR.

When a robot retracts an extended tool, the reverse choices are available: the first method would be to maintain the extended size in the JDR until the tool is fully retracted to its closed (or subsequent) position, and the second method would be to record the changing envelope on a second-by-second basis, as the tool is restored or repositioned.

Current width[5]	x	Cm

6.1.6 Navigation intention and status elements

Every mobile robot must have some way to ensure that bystanders understand their mobility intentions or status states. Simple dedicated PMRs, such as a street sweeper or a wheeled delivery robot might use sounds or lights. Whereas an ambulatory work-assistant robot with language skills might voice or gesture its intentions to proximate humans.

[4] Wouldn't it better to define a sphere or cylinder based on the furthest reach from the CoG? (Kind of like a robot's 'personal space'). Rectangular cuboids are the common way we see this visualized. Of course, that may not be the actual internal representation. Cuboid are cheap to compute and visualize in realtime. I am not sure whether other shapes offer a safety or other premium. We would have to determine that before we specify something more complex.

[5] It may also be important to identify "Current Width" as that is the most relevant when it comes to potentially obstructing other users. (this is about robots that change width because of their attached tools.)

4448-8 defines a number of navigation-related intentional states, such as “you-go-first”, “U-turn”, “excuse me”, or “I’m frightened.” Regardless of the method of generating the signal (lights, voice, gesture), the JDR shall record that such an intention has been signalled. Only a specific subset of such signals will need to be recorded and that is the subset described in 4448–8 (which is still in 1st draft).

To be clear a JDR that includes ***Navigation intention and status elements*** must have a way to include all identified intentions even though on a particular PMR certain statuses cannot be achieved. For example, the navigation intention “U-turn” is defined in this subset, and shall be recordable in any JDR that specifies this subset, even though that JDR is installed on a PMR that cannot perform a U-turn. In other words, this specifications defines completeness for the JDR irrespective of the capability of the PMR.

{robotIntention[ID]ON, T}	Robot intention signal [ID] activated at time T	{[ID], ON, timedate}
{robotIntention[ID]OFF, T}	Robot intention signal [ID] deactivated at time T	{[ID], OFF, timedate}

@lee: In 4448-8, we need to assign an ID [riNN] to each intention signal

The potential list of robot intention communications could eventually become very large, but it will not necessarily be the case that every type of communication must be recorded in a compliant JDR. As an example, sometime in the future and ambulatory robot in a hospital that happens to have it graspers full of cargo could ask “can you hold the door for me?” Because such a ***Navigation intention*** communication has not been described in 4448–8, it is not required in a complaint JDR. Because of a likely gradually expanding set of such communications, which of those would need to be recorded will probably have to be reviewed regularly for the foreseeable future.

6.2 Associated PMR details

To Do - (use the same equipment description as defined for a TripPlan)

6.3 Location/positioning data

To Do - (use the same location descriptor as used for bread-crumbs in 4448-16)

Pathway width, gradient, friction, cross gradient, plus several others at the moment of an event. They could be supplied from the PMR sensors, from the TripPlan (approximate), or optional/unknown (in the case of *Human Operation*).

6.4 Information concerning the controller

To Do – (discuss with Bob)

6.5 Date and time of an event

To Do – YYYY MM DD hh mm ss (UTC) (refer to the existing ISO standard)

6.6 Proximity record

As a PMR journey unfolds, the PMR travels (navigates) according to

- a plan (radio signals) provided entirely by an external controller (*Human Operated*)
- a plan that is partially provided in advance by an external controller and partially generated in realtime according to on-board sensors and algorithms (*Human Delegated* or *Human Supervised*)
- a plan that is entirely determined by on-board sensors and algorithms (*Fully Autonomous*)

During this navigation, the PMR (or its human operator) will be guided by rules, known inherently to the human operator and mediated via the human-activated controller system, or encoded specifically within the PMR's decision software that will have the PMR avoid collisions with proximate objects, including humans and animals that occur along the pathway of travel. These rules, whether known to a human operator or encoded, include *ShyDistances* — various prescribed spaces to leave between the PMR and objects or bystanders it encounters or passes.

Since all such distances are greater than zero, a PMR that is *always able to abide by such rules will never cause a collision.* However, external events independent of the ability of the PMR or its teleoperator, or events induced by a PMR software or hardware failure, will admit collisions or more often near-misses in which the intervening distance is less than a prescribed *ShyDistance*. Such events, or "near-misses," shall be captured and included in the JDR record.

The intention of the proximity record is to retain an evidentiary-quality recording of the lead-up to all collisions and the trajectory history of all collisions and near-misses from their commencement at R.

This proximity record enables:

1. measurement of *shyDistance* compliance
2. comparison of *shyDistance* compliance among fleet operators
3. social compliance for license renewal
4. a tool for investigating complaints
5. a record for event reconstruction
6. a tool for measuring congestion regarding the granting of TripPlans
7. a method for testing software

Considering Figure 2, Sensory Radius, R, for a PMR JDR shall be set from three to five 5 m from the center of the PMR. Object distance, D, within the radius shall be measured from the center of the PMR to the nearest edge of each object (a) within the radius. Each nearest-edge object position shall be recorded at 10+Hz in the quadrant it is detected. If an object overlaps more than one quadrant during a sample, it shall be measured and reported in each (b) (redundant detection).

The JDR is merely recording the raw distance data. While the PMR maybe observing these proximate objects and calculating closing speeds, and determining its immediate navigation path based on this information, or even concluding that a crash might be imminent, or that an act of vandalism may be in progress. All of those PMR observations are independent of the fact that the JDR is capturing these measures. There is no requirement for the JDR to calculate the closing speed of any object within this radius. That can be done off-line if and as necessary by "incident investigators" or "expert advisors" (IEEE 7001:2021) who have 10+ Hz data to reconstruct speeds.

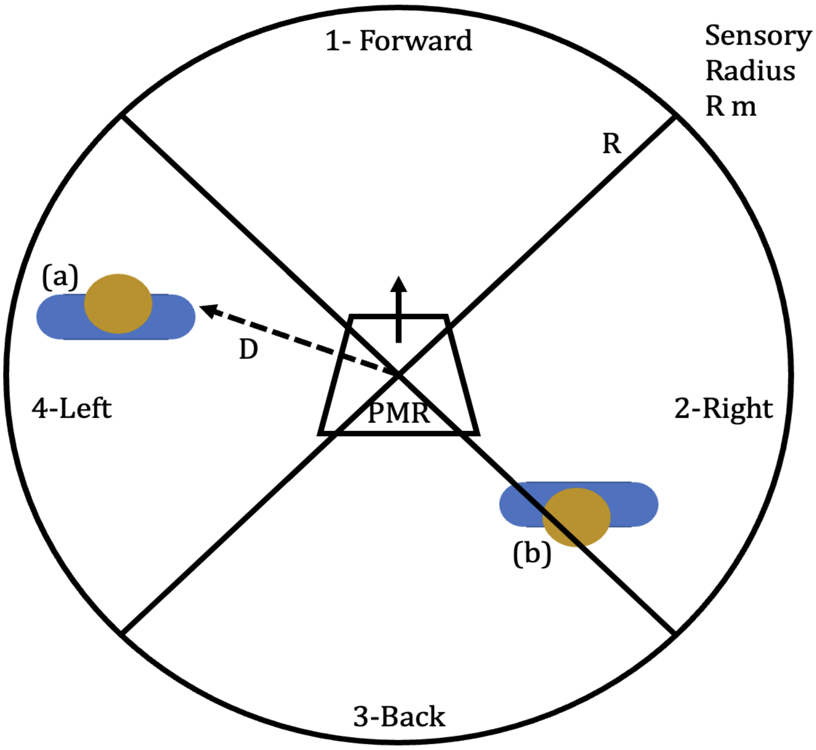

Figure 2:Recording proximate distances to dynamic objects

There will be complex circumstances, for example, multiple people, walking, hand-in-hand,[6] or a person, pushing or pulling a cart, or a person with a pet. Without images, these complex objects would often appear as more than one object, hence would be recorded as two or more objects, or if it was considered as a single object, then, only the closest point of a complex object would be considered the objective distance. We need to think more about the implication of this for incident reconstruction, especially for the interpretation of "near miss". One example where this breaks down is a pedestrian that is passing a PMR, and while the PMR is keeping correct, shyDistance, the wind blows the pedestrian's coat in a way that not only closes the shy distance, but even the brushes the PMR. These kinds of circumstances without imagery, could degrade the measured performance of the PMR.

6.7 Data elements

Each PMR fitted with a JDR shall record the data elements specified as mandatory and those required under specified minimum conditions during the interval/time and at the sample rate specified in Annex A, Table 1.

An additional source for PMR journey data elements can be found in Winfield et al [6] Annex A, table 8. These include (among others):

- Connectivity (0-255)
- Actuator values (demand and actual) — (multiple, labelled actuators)
- Sensor values (multiple) (microphone(s), camera(s), gyro(s), accelerometer(s),
- Temperatures (multiple?) internal and external
- Battery level (suggest only when below threshold (elsewhere in 4448)
- Wheel angles (add tool dispositions)
- Decision, codes and reasons (time stamped)

[6] How can PMRs determine solidity (difference between a plastic bag blowing in the wind and a pet)? Is it just using imagery or are there other methods? There are technical solutions for this, but the standard does not specify how to solve problems only the measure of their solution. Because these kinds of solutions are very expensive, I think it would be an error for us to specify that a PMR can determine object density. Our watchphrase, here, is "necessary and sufficient."

- ...more

Altogether there, a very large number of possible things that *could* be measured and included in a JDR. The goal for the selection of necessary and sufficient data elements shall be to capture all of the relevant circumstances, behaviors, decisions, outcomes in time series that are sufficient to judge two things:

1. The analysis/reconstruction of any bystander complaint or crash and with a very high likelihood of determination of fault
2. The correctness (as judged against the standard) of PMR behaviour as it navigates a public space, including all appropriate shyDistances, way-granting, robot-human communications, etc.

This latter point is for software testing and behavioural certification (for example, for fleet license renewal). The importance of this cannot be overstressed. This will be the only effective way to evaluate whether PMRs are following the "rules of the road" including the details of shyDistance management. This is the key value of the proximity record.

For certainty, no PMR can be expected to perfectly follow shyDistance rules under every circumstance. This is because bystanders will move in and out of this shyDistance radius in ways such that robots will not be able to react in time. The idea is not to make sure that a robot never breaks a shyDistance rule what matters is that robots break those rules infrequently. An analogy is how speed limits are enforced with a tolerance, allowing motorist to drive a few kilometres, but not too many, over the posted limit.

One thing that is possible to do with the proximity measure is to compare fleet behaviour behaviour between fleets that will tell us about the software capabilities of respective fleets.

6.8 Data format

6.8.1 Reporting

Each data element recorded shall be reported in accordance with the range, accuracy, and resolution specified in Annex A, Table 1. The data shall be presented in ASN.1 module. See Annex C for an example of a suitable ASN.1 module. This needs rewriting.

6.9 Data capture

6.9.1 General

The JDR shall record the captured data by the PMR and this data shall remain within the PMR subject to the provisions of paragraph 6.9.7, at least until they are retrieved in compliance with national or regional legislation or they are overwritten in compliance with paragraph 6.9.7 (overwriting)

The JDR non-volatile memory buffer shall accommodate the data related to at least two different events.

The data elements for every event shall be captured and recorded by the JDR, as specified in Clause 6.6? in accordance with the following conditions and circumstances:

6.9.2 Data Capture Frequency

Data shall be captured in four frequencies.

1. Some items are captured **only once** on JDR start up such as JDR startup time, PMR descriptive and ID information, JDR descriptive and ID information. These are things that do not change, but must be known in order to use the data that is to be captured. This must be captured once for

every JDR record. For example, if the JDR is shut down during battery charging, and restarted at the beginning of the next duty cycle, then this information must be re-captured.

2. Some items are captured **occasionally**, such as battery level, temperatures, etc. An example of occasionally might be 15 minutes
3. Some items are captured **infrequently**, such as gross weight, speed, travel gradient, etc. An example of infrequently might be five minutes.
4. Some items are captured **frequently**, such as shy distances within the proximity ellipse. An example of frequently might be to 2 Hz.

The definitions for occasionally, infrequently, and frequently, need to be determined, and could be made variable. But they shall be set in a way to ensure effective analysis.

6.9.3 Conditions for triggering recording of event data

I do not understand this use of the word "recording." Recording must have continuously preceded a crash (or vandalism, or near-miss) event in order to capture the lead up to the event. What happens after such an event is that the recording is continued, retained, (not overwritten). This needs to be changed and subsequent clauses need to be independent of whether or not a PMR is transporting a human. If a PMR is transporting a human, the navigational behaviours of such a PMR are subject to 4448, but the human contact elements (such as seatbelts) or not in scope of 4448. Such elements can be added to an incremental data segment of the JDR, but that would be an extension.

Would changing 'recording' to 'registering' satisfy the concern expressed in the orange text?

These next sub clauses need to be reviewed. They seem to be coming from motor vehicle specifications. (human occupant-related matters are out of scope)

~~An event shall be recorded by the JDR if one of the following threshold values is met or exceeded:~~

~~6.9.2.1. Change in longitudinal PMR velocity more than 8 km/h within a 150 ms or less interval~~

~~6.9.2.2. Change in lateral PMR velocity more than 8 km/h within a 150 ms or less interval~~

~~Does acceleration of 8 km/h within 150ms scale to PMRs that travel at 6 km/h This needs to be changed to a relative calculation~~

~~Wouldn't the answer be 53 km/s2?~~

The next clause relates to devices carry humans. While the mobility of such devices, when in public spaces are subject to the standard, the human, touching, and human safety aspects of the human that is riding in or on the device is out of scope.

~~6.9.2.3. Activation of VRU secondary safety system~~

~~If a PMR is not fitted with any VRU secondary safety system, this specification requires neither recording of data nor fitting of such systems. However, if a PMR is fitted with such a system, then it is mandatory to record the Journey Data following activation of this system.~~

The intention of the JDR is to record the journey, in particular, the proximity record, and other elements that support that record. That implies a continuous recording that could overwrite itself if there are no events worth saving. So we would not be talking about "triggering recording" but we would be talking about "locking in a recording".

6.9.4 Conditions for triggering locking of data

In the circumstances provided below, the memory for the event shall be locked to prevent any future overwriting of the data by subsequent events.

~~6.9.3.1. In all the cases where a non-reversible occupant restraint system is deployed (where a PMR is transporting a human passenger). [Bob suggests "Move to Annex B"; Bern thinks "out of scope"]~~

~~6.9.3.2. In the case of a frontal impact, if the PMR is not fitted with a non-reversible restraint system for front impact, when the PMR's velocity change in x-axis direction exceeds 25 km/h within 150ms (167 km/s2) or less interval.~~

~~6.9.3.3. Activation of vulnerable road user secondary safety system.~~

~~6.9.5 Acceleration Time-History data and format~~

~~The longitudinal, lateral, and normal acceleration time-history data, as applicable, shall be filtered either during the recording phase or during the data downloading phase to include:~~

~~6.9.4.1. The Time Step (TS) that is the inverse of the sampling frequency of the acceleration data and which has units of milliseconds.~~

~~6.9.4.2. The number of the first point (NFP), which is an integer that when multiplied by the TS equals the time relative to time zero of the first acceleration data point.~~

~~6.9.4.3. The number of the last point (NLP), which is an integer that when multiplied by the TS equals the time relative to time zero of the last acceleration data point; and~~

~~6.9.4.4. NLP—NFP + 1 acceleration values sequentially beginning with the acceleration at time NFP * TS and continue sampling the acceleration at TS increments in time until the time NLP * TS is reached.~~

~~6.9.6 Conditions for establishment of time zero~~

~~Time zero is established at the time when any of the following first occurs:~~

~~6.9.5.1. For systems with "wake-up" air bag control systems, the time at which the occupant restraint control algorithm is activated (where a PMR is designed for transporting a human passenger).; or~~

~~6.9.5.2. For continuously running algorithms,~~

~~6.9.5.2.1. The first point in the interval where a longitudinal, cumulative delta-V of over 0.8 km/h is reached within a 20 ms time period; or~~

~~6.9.5.2.2. For PMRs that record "delta-V, lateral," the first point in the interval where a lateral, cumulative delta-V of over 0.8 km/h is reached within a 5 ms time period; or~~

~~6.9.5.3. Deployment of a non-reversible deployable restraint (where the PMR is transporting a human passenger) or activation of VRU secondary safety protection system. [Bob suggests "Move to Annex B"; Bern thinks "out of scope"]~~

6.9.7 Conditions for recording the Proximity Record

The continuous 2Hz (more?) recording of all distances of proximate objects within a close radius shall run continuously while a PMR is on-task or in-public (i.e., always when on duty or moving in a public space. This record may (shall?) be overwritten after 30 minutes in the absence of any event. It shall be retained in the case of an event.

Note that this recording shall continue when the PMR is immobile such as waiting for a pedestrian to pass, waiting to cross a road or other pathway, waiting for a human to remove its payload, change its tool, etc. This is because it is possible for an event to occur to the PMR while the PMR is in such a wait-state.

Should we find a way to declare vandalism (a form of proximity and form of harm) and capture that event?

Could vandalism be defined as when the PMR experiences a certain level of acceleration while stationary and in proximity of a human? (and without the radio signal that indicates a collaborator or receiver.) If a human operated vehicle intentionally crashes into a PMR, that would still be a crash. If an animal attacks the PMR, that could be defined as an animal attack.

This is a fraught issue. Examples: [1] a bystander waiting at the intersection brushes her shopping bag accidentally against the PMR; [2] a dog urinates on the PMR (the owner is not paying attention); [3] a child comes by and pets the robot, because it likes its smiley face; [4] a sharp gust of wind accelerates the PMR just over the "vandalism threshold." I propose that we rely on the proximity record to sort out all of these mixed types of false alarms from actual meaningful (property-destructive) vandalism. If imagery that has been captured in the course of maintaining the "surround-awareness ellipse" for meso planning (4448–16, 4.2.1, Figures 2&3) is permitted in evidence, then most of these circumstances can be easily sorted and resolved. Vandalism can be ***physically*** destructive, such as striking, tipping, opening, and stealing. Vandalism can be ***disruptive*** without harming the equipment, such as painting, urinating, spitting, blocking its path (a prank), throwing something on top of it to blind it (a blanket or mud), or a rope around its wheels to snag it. In other words, vandalism can be physically destructive of the device, or it can be disruptive of the task that is being executed. And there are a lot of innocent things that could easily be mistaken for vandalism if there is no image capture. This would give rise to a lot of false alarms. Which is a considerable negative.

We need to build a strong case for image retention triggered by events in the proximity record (4448-20, 1.17) such that the imagery can be used in defense of PMRs and fleet operators (this means it can also be used against them if the PMR — possibly the teleoperator — is at fault). A key argument here is that vandalism that disables machines endangers the community in which those machines are damaged. The reduction of vandalism is better for everyone. Vandalism harms everyone except perhaps the vandal.

6.9.8 Overwriting

6.9.7.1. If a JDR non-volatile memory buffer void of previous-Journey Data is not available, the recorded data shall, subject to the provisions of paragraph 6.9.3, be overwritten by the current Journey Data, on a first-in first-out basis, or according to different strategies decided by the manufacturer and made available to the relevant authorities as determined by local or national regulations.

6.9.7.2. Furthermore, if a JDR non-volatile memory buffer void of previous-Journey Data is not available, data originating from non-reversible restraint system or vulnerable road user secondary safety system deployment events referred to in paragraph 6.9.3 shall always overwrite any other data that is not locked per 6.9.3.

6.9.9 Power failure

Data recorded in non-volatile memory shall be retained after loss of power.

6.10 Deactivation

It shall not be possible to deactivate the Journey Data Recorder

7 Annexes are not yet incorporated

These annexes need considerable work. They are not ready for comment.

Annex A

(Normative)

Data elements and format

A.1 Data elements

Data elements and format

Table 1 data elements

NOTES

1 Format requirements specified below are minimum requirements and manufacturers can exceed them.

2 "Mandatory" is subject to the conditions detailed in Section 1.

3 Pre-event data and event data are asynchronous. The sample time accuracy requirement for pre-event time is -0.1 to 1.0 sec (e.g., T = -1 would need to occur between -1.1 and 0 seconds.)

4 Accuracy requirement only applies within the range of the physical sensor. If measurements captured by a sensor exceed the design range of the sensor, the reported element shall indicate when the measurement first exceeded the design range of the sensor.

5 "Planar" includes triggered events in sections 5.8.1.1, 5.8.1.2, and 5.8.1.3 and "VRU" includes triggered events in section 5.8.1.4.

6 The ignition cycle at the time of download is not required to be recorded at the time of the event but shall be reported during the download process.

7 "If recorded" means if the data is recorded in non-volatile memory for the purpose of subsequent downloading.

8 May be recorded in any time duration; -1.0 to 5.0 sec is suggested

These elements do not need to meet accuracy and resolution requirements in specified crash tests.

Manufacturers can include other system states

Data element	Condition for requirement 2	Recording interval/time 3 (relative to time zero)	Data sample rate (samples per second)	Minimum range	Accuracy 4	Resolution	Event(s) recorded for 5
Delta-V, longitudinal	Mandatory - not required if longitudinal acceleration recorded at ≥500 Hz with sufficient range and resolution to calculate delta-v with required accuracy	0 to 250 ms or 0 to End of Event Time plus 30 ms, whichever is shorter.	100	-100 km/h to + 100 km/h.	±10%	1 km/h.	Planar
Maximum delta-V, longitudinal	Mandatory - not required if longitudinal acceleration recorded at ≥500 Hz	0–300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter.	N/A	-100 km/h to + 100 km/h.	±10%	1 km/h.	Planar
Time, maximum delta-V, longitudinal	Mandatory - not required if longitudinal acceleration recorded at ≥500 Hz	0–300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter.	N/A	0–300 ms, or 0- End of Event Time plus 30 ms, whichever is shorter.	±3 ms	2.5 ms.	Planar
Speed, PMR indicated	Mandatory	-5.0 to 0 sec	2	0 km/h to 250 km/h	±1 km/h	1 km/h.	Planar VRU Rollover
Engine throttle, % full (or accelerator pedal, % full)	Mandatory	-5.0 to 0 sec	2	0 to 100%	±5%	1%	Planar VRU Rollover
Service brake, on/off	Mandatory	-5.0 to 0 sec	2	On or Off	N/A	On or Off.	Planar VRU Rollover
Ignition cycle[6], incident	Mandatory	-1.0 sec	N/A	0 to 60,000	±1 cycle	1 cycle.	Planar VRU Rollover
Ignition cycle[6], download	Mandatory	At time of download[7]	N/A	0 to 60,000	±1 cycle	1 cycle.	Planar VRU Rollover
MOVE TO ANNEX B (Bob) **Aspects about human passengers are out of scope (Bern)** Safety belt status, (where the PMR is equipped to transport a human passenger).	Mandatory	-1.0 sec	N/A	Fastened, not fastened	N/A	Fastened, not fastened	Planar VRU Rollover
Multi-event event, number of events	If Recorded[7]	Event	N/A	1 or more	N/A	1 or more.	Planar VRU Rollover
Time from event 1 to 2	Mandatory	As needed	N/A	0 to 5.0 sec	±0.1 sec	0.1 sec.	Planar Rollover

7

Data element	**Condition for requirement** [2]	**Recording interval/time** [3] (relative to time zero)	**Data sample rate** (samples per second)	**Minimum range**	**Accuracy** [4]	**Resolution**	**Event(s) recorded for** [5]
Complete file recorded (yes, no)	Mandatory	Following other data	N/A	Yes or No	N/A	Yes or No.	Planar VRU Rollover
Lateral acceleration (post-event)	If Recorded	0–250 ms or 0 to End of Event Time plus 30 ms, whichever is shorter.	500	-50 to +50g	+/- 10%	1 g	Planar Rollover
Longitudinal acceleration (post-event)	If Recorded	0–250 ms or 0 to End of Event Time plus 30 ms, whichever is shorter.	500	-50 to +50g	+/- 10%	1 g	Planar
Normal acceleration (post-event)	If recorded	-1.0 to 5.0 sec[8]	10 Hz	-5 g to +5 g	±10%	0.5 g	Rollover
Delta-V, lateral	Mandatory - not required if lateral acceleration recorded at ≥500 Hz and with sufficient range and resolution to calculate delta-v with required accuracy	0–250 ms or Event Time plus 30 ms, whichever is shorter.	100	-100 km/h to + 100 km/h.	±10%	1 km/h.	Planar
Maximum delta-V, lateral	Mandatory - not required if lateral acceleration recorded at ≥500 Hz	0–300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter.	N/A	-100 km/h to + 100 km/h.	±10%	1 km/h.	Planar
Time maximum delta-V, lateral	Mandatory - not required if lateral acceleration recorded at ≥500 Hz	0–300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter.	N/A	0–300 ms, or 0- End of Event Time plus 30 ms, whichever is shorter.	±3 ms	2.5 ms.	Planar
Time for maximum delta-V, resultant.	Mandatory - not required if relevant acceleration recorded at ≥500 Hz	0–300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter.	N/A	0–300 ms, or 0-End of Event Time plus 30 ms, whichever is shorter.	±3 ms	2.5 ms.	Planar
DROP? (Bern) Engine rpm	Mandatory	-5.0 to 0 sec	2	0 to 10,000 rpm	±100 rpm[10]	100 rpm.	Planar Rollover
Vehicle roll angle	If recorded	-1.0 up to 5.0 sec[9]	10	-1080 deg to + 1080 deg.	±10%	10 deg.	Rollover
ABS activity	Mandatory	-5.0 to 0 sec	2	Faulted, Active, Intervening[10]	N/A	Faulted, Active, Intervening[12]	Planar VRU Rollover

Data element	Condition for requirement [2]	Recording interval/time[3] (relative to time zero)	Data sample rate (samples per second)	Minimum range	Accuracy[4]	Resolution	Event(s) recorded for[5]
Stability control	Mandatory	-5.0 to 0 sec	2	Faulted, On, Off, Intervening[1] [2]	N/A	Faulted, On, Off, Intervening[1] [2]	Planar VRU Rollover
Steering input	Mandatory	-5.0 to 0 sec	2	-250 deg CW to + 250 deg CCW.	±5%	±1%.	Planar VRU Rollover
MOVE TO ANNEX B (Bob) Aspects about human passengers are out of scope (Bern) Safety belt status (where the PMR is equipped to transport a human passenger).	Mandatory	-1.0 sec	N/A	Fastened, not fastened	N/A	Fastened, not fastened	Planar Rollover
MOVE TO ANNEX B (Bob) Aspects about human passengers are out of scope (Bern) Pretensioner Mandatory deployment, time to fire, driver,(where the PMR is equipped to transport a human passenger).	Event	N/A	0 to 250 ms	±2 ms	1 ms.		Planar Rollover

Annex B

(Normative) **Additional features and data for specialised PMR use cases**

B.1 Clause title

To Do

Annex C

Example of an ASN.1 module for the data maintained in a PMR JDR

C.1 Clause title

To Do

NOTE: Abstract Syntax Notation One (ASN.1) is a standard interface description language for defining data structures that can be serialized and deserialized in a cross-platform way. It is broadly used in telecommunications and computer networking, and cryptography.

The advantage of ASN.1 presentation is that it is unambiguous and the ASN.1 description of the data encoding is independent of any particular computer or programming language.

ASN.1 is a joint standard of the International Telecommunication Union Telecommunication Standardization Sector (ITU-T) in ITU-T Study Group 17 and ISO/IEC, 8824 and 8825 series of standards. It was originally defined in 1984 as part of CCITT X.409:1984. In 1988, ASN.1 moved to its own standard, X.208, due to wide applicability. The substantially revised 1995 version is covered by the X.680 series. The latest revision (at the time of development of this document) of the X.680 series of recommendations is the 6.0 Edition, published in 2021.

Annex D

(Normative)

Information document to be available for a PMR type with regard to its Journey Data Recorder (JDR)

A.1 Information document to be available for a PMR type with regard to its Journey Data Recorder (JDR)

A list of contents shall be included.

Any drawings shall be supplied in appropriate scale and in sufficient detail on size A4 paper or on a folder of A4 format.

Photographs, if any, shall show sufficient detail.

General

- Trade name or mark of the PMR:
- PMR type:
- Means of identification of type, if marked on the PMR:
- Location of the marking:
- Location of and method of affixing the approval mark:
- Category of PMR:
- Name and address of manufacturer:
- Address(es) of assembly plant(s):
- Photograph(s) and/or drawing(s) of a representative PMR:
- JDR
    - Make (trade name of manufacturer):
    - Type and general commercial description(s):
    - Drawing(s) or photographs showing the location and method of attachment of the JDR in the PMR:
    - Description of the triggering parameter:
    - Description of any other relevant parameter (storing capacity, resistance to high deceleration and mechanical stress of a severe impact, etc.):
    - Instructions for retrieving data from the JDR
    - The data elements and data format stored in the JDR:

Data element	*Recording interval/time (relative to time zero)*	*Data sample rate (samples/second)*	*Minimum range*	*Accuracy*	*Resolution*

Bibliography

[1] UN E/ECE/TRANS/505/Rev.3/Add.159 'Agreement Concerning the Adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulations

[2] UNECE Working Party 29, UN Regulation No. 160
Agreement
Concerning the Adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulations*
(Revision 3, including the amendments which entered into force on 14 September 2017)

Addendum 159 – UN Regulation No. 160
Date of entry into force as an annex to the 1958 Agreement: 30 September 2021

https://unece.org/transport/documents/2021/10/standards/un-regulation-no-160-event-data-recorder-edr

[3] Durst, P.J. and M. Gray. "Levels of autonomy and autonomous system performance assessment for intelligent unmanned systems," ERDC/GSL SR-14-1, 2014.21

[4] ISO #####-##:20##, *General title — Part ##: Title of part*

[5] Salvini, P., Paez-Granados, D., Billard, A. (2021) - *On the Safety of Mobile Robots Serving in Public Spaces: Identifying gaps in EN ISO 13482:2014 and calling for a new standard*

[6] Winfield AF, van Maris, A., Salvini, P., and Marina Jirotka, M. (2022) *An Ethical Black Box for Social Robots: a draft Open Standard*

Working notes Bern to Bob (not part of the standard):

[1:] We say NO AUDIO/VIDEO in one place, but include it another. If there is to be no audio/video in the JDR, then we should not discuss audio/video here. HOWEVER, the short JDR loop drafted in Figure 2 could be twinned with an audio/video loop and destroyed/retained on the same cycle. It would then be part of the JDR.

However, I am thinking that a video audio recording would be very complex to standardize (especially if you consider privacy rules, so I think I understand why you thought there should be no audio/video within the JDR itself. Probably we should think through this a little more thoroughly.

[2:] (edited) There are many aspects related to restraining human passengers. These need to be here because of the potential of such carriage. However, many, and almost certainly the majority, of PMRs will not have human passengers, so the JDR on such devices could be simpler. I propose to mark some fields optional for PMRs that cannot/will not carry humans and animals (i.e., not need passenger restraints).

So, I'm thinking about those differences as two subsets:

- Data for ANY PMR
- Data for a PMR that is able/intended to carry humans or animals (assumes they might/must have crash restraints for the passenger; you have likely covered these) **LATER**

My major focus regarding PMRs that do not admit human/animal carriage (delivering, ploughing, monitoring, mopping, sweeping, salting) is that they must follow a body of "rules of the road" and "rules about retaining distances from pedestrians" that they cannot always honour (e.g., leave X distance to proximate humans, wait beside/away from the pedestrian throughway, navigate left or right but cannot, etc.). I think the JDR should be recording each broken rule at 1HZ. So the job is to:

- list the rules that matter for JDR monitoring
- have a {name, unit, measure} for each rule (most exist in 4448-2 and a few elsewhere)

Because the actual measures for each rule are set by the local regulatory jurisdiction, the instance of an infraction differs between such jurisdictions. So I struggled with whether to record the local error or always to record the physical event regardless of whether it is out of spec. For example, if a PMR is to keep 20 cm distance away from pedestrians in jurisdiction-1 but 24 cm away in jurisdiction-2, then at 22 cm, there is no error in jurisdiction-1 but a 2 cm error in jurisdiction-2.

This would make the description overly complicated...

WHEN a PMR is using a TripPlan, this is simple, because the TripPlan contains the local, real-time rules for these behaviours so the JDR need only record infractions. BUT this means that the decoding of a JDR recording requires a matching TripPlan. But what if there is no TripPlan? (e.g., a jurisdiction that does not use an orchestration system - which will be many!). This means that we'd need to record all applicable measures even when in compliance and even if there is no event precipitated by a dramatic acceleration. I think we must ("shall") record all necessary and sufficient data regardless of regional differences.

We also need to determine a scheme so that any new rule added to 4448-x can be easily added to 4448-20 *when deemed important to record* (especially on the transparency principle!) (we are not recording everything in a TripPlan).

