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Exoskeleton Terminology and Taxonomy

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Taxonomy

	Military	Industrial	Medical
Anatomy based			
Upper extremity - *arms, shoulder, elbow, combination*			
Lower extremity - *hip, knee, ankle, combination*			
Torso Load Re-distribution			
Helmet Load Re-distribution			
Full body			
Task based			
Improve mobility / agility			
Load handling, load positioning			
Increase endurance, strength, capabilities			
Increase productivity			
Mission support - soldier readiness			
Rehabilitation			
Environment			
Indoor clean			
Indoor dirty			
Outdoor (dusty, dry, damp)			
Outdoor (extremes: dirty, dry, wet)			
System Mobility based			
Stationary			
Tethered			
Untethered			

Taxonomy

Exoskeleton Structure	Military	Industrial	Medical
Mechanical Actuation			
Hydraulic			
Electromechanical (incl. cable)			
Pneumatic			
Spring			
Power/Control			
Powered/Active			
Quasi Active			
Unpowered/Passive			
Kinetic Energy Harvesting			
Oscillating mass			
Relative human joint motion			

Related Standards

Terminology

- ISO/TC 299/WG 1 Vocabulary and characteristics
  - ISO 8373:2012 Robots and robotic devices — Vocabulary
- ISO/TC 173/SC 2 Classification and terminology
  - ISO 9999:2016 Assistive products for persons with disability -Classification and terminology
- ASTM F3200-16 Standard Terminology for Automatic Guided Industrial Vehicles
- E2521-07a: Standard Terminology for Urban Search and Rescue Robotic Operations
- ISO/CD 19649 Robots and robotic devices ---Vocabulary for mobile robots (under development)
- IEEE 1872-2015 Standard for Ontologies for Robotics and Automation (some terms/definitions)

- ISO 8373 contains basic terms which relate to all robotic fields.
- At this time, there are no specific terms related to exoskeletons.
- Expected in the near future is that some terms will be developed during development of a performance or safety standard on exoskeletons.
- After these are finished, “we will look into the possibility of putting these new terms into ISO 8373 when we revise it.”

NIST

Development of ASTM F45.91 Terminology Standard F3200-16
Potential Information Towards Exoskeleton Terminology Standard

- May 2014 – ASTM Committee F45 (55 members) was formed along with ASTM F45.91 Terminology subcommittee (20+ members)
  - Formed a task group of 8 members
- Searched terminology standards, vehicle standards, MHIA website, etc. terminology listings
- Compiled terms that pertain to autonomous vehicles and testing into a single document with reference to their origin
- Held monthly webex task group and bi-annual full committee face-to-face meetings:
  - TG made an initial pass through the list to remove/add terms that may be useful to F45 documents
  - TG meetings used to form a consensus on each and every term, lots of discussion on over 120 terms
  - Face-to-face meetings allowed full group to provide comments on terms, definitions
- Balloted ~120 terms to F45.91 subcommittee
- Resolved negative comments
- Balloted to full F45 committee
- Resolved negative comments
- ~ 70 terms passed ballot May 2016 along with the document scope which created the initial terminology standard
- Revised terms that did not pass ballot, discussed with negative voters directly
  - Many times, misunderstandings of voting process, terms use in other documents (i.e., may not be an industry use term), etc.
- Re-balloted remaining terms, addressed negatives until all terms passed – January 2017 final ~100 terms passed

Designation: F3200 – 16

Standard Terminology for Driverless Automatic Guided Industrial Vehicles[1]

This standard is issued under the fixed designation F3200; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This terminology covers terms associated with unmanned (that is, driverless), ground (that is, land-based and in continuous contact with the ground), industrial vehicles. By providing a common and consistent lexicon, the purpose of this terminology is to facilitate communication between individuals who may be involved in the research, design, deployment, and use of unmanned ground vehicles, including but not limited to, for manufacturing, distribution, security, etc. The terminology covers terms used in performance test methods of automatic guided vehicles (AGVs), autonomous mobile robots, and all other driverless, ground vehicles. In addition, with increasingly intelligent vehicle systems with onboard equipment, robotics industry terms that are used in associated test methods and descriptions are also included.

1.2 For the terminology to be harmonious with the practices in the field, definitions have been drawn from the literature or other public sources when possible. When no definition is available, is similar but requires change for use within standards produced by Committee F45, or in dispute, a consensus-based approach will be used to resolve definitions and add them to the lexicon. The development of this terminology is taking place in close coordination with corresponding efforts in all Committee F45 subcommittees to ensure comprehensive and consistent coverage.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ANSI/ITSDF Standard:*[2]

ANSI/ITSDF B56.5 Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles

2.2 *ISO Standard:*[3]

ISO 8373 Robots and Robotic Devices—Vocabulary

3. Terminology

3.1 *Definitions:*

Ackermann steer, *n*—kinematic configuration for vehicles with pairs of wheels in which the front or rear wheels are pivoted to achieve steering.

Discussion—The pivot angles of each wheel within the pivoted set are calculated such that each wheel's axle intersects a common point. This common point serves as the instantaneous center of the vehicle's turning circle.

adaptive control, *n*—control scheme whereby the control system parameters are adjusted from conditions detected during the process.

aisle, *n*—in a facility, the passageway between locations where temporary or permanent obstructions may exist.

ambient temperature, *n*—temperature of the atmosphere surrounding equipment.

automatic data capture, *n*—identification and direct collection of data into a computer system or other microprocessor-controlled device without using a keyboard (for example, technologies that support the function are: barcode, radio frequency data communication, radio frequency identification, and other emerging technologies).

Discussion—Other similar terms are *automatic data collection* or *automatic identification*.

barcode reader, *n*—device used to read a barcode; *see* **A-UGV system**.

benchmarking, *v*—measurement process that can be used for comparison against established goals, operating targets, and performance expectations.

braking, *v*—any controlled or emergency means to slow or stop the vehicle. **ANSI/ITSDF B56.5**

collision prevention, *n*—use of sensors to detect the presence of obstacles and, through the use of integrated controls, prevent a collision from occurring; *see also* **obstacle avoidance**.

qualified person, *n*—person who, by possession of a recognized degree or certificate of professional standing or extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter and work. **ANSI/ITSDF B56.5**

radio controlled, *adj*—means by which a material-handling device or piece of equipment is controlled by receiving commands via radio frequencies sent to an onboard receiver and allows the equipment or device to be controlled remotely.

rated capacity, *n*—load, its position, and the vehicle speed, as established by the manufacturer, at which design and performance can be expected. **ANSI/ITSDF B56.5**

rated speed, *n*—speed, as established by the manufacturer, at which design performance can be expected. **ANSI/ITSDF B56.5**

reprogrammable, *adj*—designed so that the programmed motions or auxiliary functions can be changed without physical alteration. **ISO 8373**

Discussion—Task planning can include autonomous and user-generated task planning.

test settings, *n*—all variables for a particular test method including those of the apparatus, method, and procedure.

test supervisor, *n*—person responsible for setting up the apparatus, instrumentation, directing, and reporting results of the test according to the test requestor or test sponsor.

test technician, *n*—person(s) responsible for executing the test procedures under supervision of the test supervisor.

trajectory control, *n*—continuous path control with a programmed velocity profile. **ISO 8373**

travel surface, *n*—terrain on which the A-UGV travels. **ISO 8373**

unit load A-UGV, *n*—A-UGV that carries a load on or within the vehicle.

vehicle path, *n*—actual path of the vehicle.

vehicle trajectory, *n*—path in time.

world coordinate system, *n*—stationary coordinate system referenced to earth that is independent of the vehicle.

4. Keywords

4.1 A-UGV; automatic guided vehicle (AGV); driverless automatic guided industrial vehicles; industrial; mobile robot; mobility

BIBLIOGRAPHY

(1) Material Handling Industry of America, *Automatic Guided Vehicle Systems*, http://www.mhi.org/glossary, 2014.

[1] This terminology is under the jurisdiction of ASTM Committee F45 on Driverless Automatic Guided Industrial Vehicles and is the direct responsibility of Subcommittee F45.91 on Terminology.

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[2] Available from Industrial Truck Standards Development Foundation, 1750 K St., NW, Suite 460, Washington, DC 20006, http://www.itsdf.org.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.