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Standard Guide for Set of Objects used with A-UGVs[1]

This standard is issued under the fixed designation F3588; 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 standard guide provides a standard set of reference objects for use with automatic, automated, or autonomous unmanned ground vehicles (A-UGVs). The objects set includes typical objects found within industrial areas including, but not limited to: warehouses, hospitals, office spaces, and manufacturing facilities. Also, the objects set includes three test pieces from ANSI/ITSDF B56.5. The objects set is intended for use by A-UGV manufacturers and users to test the performance of A-UGVs when near the object(s). The objects set is minimized to include characteristics that have proven to cause interrupted A-UGV operation. Beyond this set of objects, Test Method F3418 is used to record most any object.

1.2 The objects set contains one each of the following items: pallet, racking, ladder, cable cover, table, cart, intravenous (IV) pole, chair, forklift tines, and test pieces shown in ANSI/ITSDF B56.5, including a horizontal cylinder, vertical cylinder, and flat plate. The objects set is not intended to be exhaustive.

1.3 It is intended that the objects set mainly includes off-the-shelf items. This standard guide provides a reporting method to provide obstacle information (for example, model, serial number, photograph) to allow obstacle use for exact replication of tests.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are not precise mathematical conversion to imperial units. They are close approximate equivalents for the purpose of specifying material dimensions or quantities that are readily available to avoid excessive fabrication costs of test apparatuses while maintaining repeatability and reproducibility of the test method results. These values given in parentheses are provided for information only and are not considered standard.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3200 Terminology for Driverless Automatic Guided Industrial Vehicles

F3244 Test Method for Navigation: Defined Area

F3381 Practice for Describing Stationary Obstacles Utilized within A-UGV Test Methods

F3418 Test Method for Measurement of Transition Temperatures of Slack Waxes used in Equine Sports Surfaces by Differential Scanning Calorimetry (DSC)

F3470 Guide for A-UGV Capabilities

2.2 *Other Standards:*

ANSI/ITSDF B56.5 Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles[3]

3. Terminology

3.1 Generic terminology for this guide is referenced in Terminology F3200.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *standard object, n*—a select item in the environment that is not infrastructure.

3.2.1.1 *Discussion*—Standard objects are selected through survey or ballot, or both, by ASTM Committee F45 and are commonly found within A-UGV environments.

4. Significance and Use

4.1 A-UGVs navigate, dock, or perform other tasks, or combinations thereof, within for example manufacturing, warehouse, hospital, and other environments. Objects (defined

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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in Terminology F3200 as anything in the environment that is not infrastructure) and obstacles (defined in Terminology F3200 as static or moving objects that obstruct the intended movement) are common within these environments. Objects can cause A-UGV challenges in navigation, docking, etc. (see Test Method F3244, Guide F3470) where the object detection systems must provide the highest level of performance to allow safe and productive vehicle use. ASTM Committee F45 surveyed the A-UGV community of manufacturers, users, and researchers, and determined that a relatively short list of objects are the most common objects that their vehicles must detect and avoid. Additionally, ANSI/ITSDF B56.5 includes three test pieces that represent *(1)* the human body torso lying horizontally and *(2)* standing human leg, both with worst case, flat black coatings, and *(3)* flat objects (for example, boxes, doors, manufactured materials), including a worst case, highly (optically) reflective coating. The survey results are listed here and are considered example objects found in warehousing/manufacturing, healthcare, domestic, and retail environments:

4.1.1 Pallets, racking, wheeled carts;
4.1.2 Other A-UGVs or AMRs;
4.1.3 Steps or stairs;
4.1.4 Tables or desks, ladders;
4.1.5 Cables or hoses, or both;
4.1.6 Chairs, overhangs (that is, on objects);
4.1.7 IV poles; and
4.1.8 Forklifts/forklift tines.

As some objects may not be cost-effectively available for only A-UGV object detection tests (for example, 4.1.2, 4.1.3, and 4.1.8), the remaining objects are potentially more cost-effective as objects and are described in this guide as the standard set of objects.

4.2 The objects can vary greatly within their category. For example, pallets can be made of wood, plastic, or metal; have a variety of dimensions; can have wheels or no wheels on the bottom; are not coated or coated with varying reflective coatings. As such, the standard objects set provided in this guide describes a specific set of objects and characteristics that are highly repeatable across their users.

4.3 The number of objects within the set is expected to increase as A-UGVs improve in capabilities and intelligence, and therefore, where A-UGV implementations expand.

5. Objects

5.1 This section provides a description of a set of standard objects, which may also be obstacles, that were selected by ASTM Committee F45 to be common in A-UGV environments and that can be used to test A-UGV obstacle detection and avoidance performance.

5.2 The standard set of objects do not include nor are representative of all objects common within A-UGV environments. The object set provides a representative object set that allows repeatable testing between A-UGV manufacturers, users, and researchers. The objects can be constructed (for example, pallet, table), if necessary, by the user as described in 5.4. When not constructed, the exact model name and number shall be provided.

5.3 The exact objects shown in this guide allow for test replication. In the event that the exact object described herein is not available, an object with features, coatings, and all other specifications should be used with full specifications and description provided on the report form provided in Practice F3381, such that test replication can occur.

5.4 The standard set of objects are listed and described as follows:

5.4.1 *Pallet*—The standard pallet, as shown in Fig. 1, is commonly used to hold goods or equipment, and is moveable using a forklift or pallet jack. The example pallet included in the set of standard objects in this guide includes the following specifications:

5.4.1.1 Wood GMA (Grocery Manufacturers Association) pallet;[4]

NOTE 1—In 2020, Grocery Manufacturers Association (GMA) changed to the Consumer Brands Association (CBA).

5.4.1.2 *Size*—122 cm wide by 102 cm deep by 12 cm high (48 in. wide by 40 in. deep by 4.75 in. high);

5.4.1.3 *Top*—A 14 cm by 102 cm (5½ in. by 40 in.) board on each end and five 9 cm by 102 cm (3½ in. by 40 in.) boards in the center, all boards 1.6 cm (0.625 in.) thick;

5.4.1.4 *Bottom*—A 14 cm by 102 cm (5½ in. by 40 in.) board on each end and three 9 cm by 102 cm (3½ in. by 40 in.) boards between the notches, all boards 1.6 cm (0.625 in.) thick;

5.4.1.5 *Stringers*—122 cm long by 9 cm high by 4 cm thick (48 in. long by 3.5 in. high by 1.5 in. thick) stringers;

5.4.1.6 *Capacity*—1136 kg (2500 lb);

5.4.1.7 *Fork Access*—4-way;

5.4.1.8 *Weight*—19 kg (42 lb); and

[4] iGPS, Standard GMA Pallet Dimensions: Why 48"X40" Uniformity Matters, https://igps.net/blog/2018/06/21/standard-gma-pallet-dimensions-why-48x40-uniformity-matters/, accessed April 7, 2022.

FIG. 1 Pallet

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5.4.1.9 No coating.

5.4.2 *Rack*—Rack, as shown in Fig. 2, is commonly used in warehouses and manufacturing facilities, among other organizations, and used as shelving for pallets, goods and equipment. The rack shown includes wire mesh shelving and adjustable height shelving rails. The example rack included in the set of standard objects in this guide includes the following specifications:

5.4.2.1 *Model*—Steel starter unit, teardrop construction, roll formed pallet rack style, fully-welded, steel teardrop frame design, Rack Manufacturer's Institute (RMI) certified boltless assembly;

5.4.2.2 *Material*—Steel;

5.4.2.3 *Dimensions*—320 cm wide by 91 cm deep by 244 cm high; usable width: 305 cm (126 in. wide by 36 in. deep by 8 ft high; usable width: 120 in.);

5.4.2.4 *Capacity*—9750 kg (21 450 lb) at 91 cm (36 in.) vertical beam spacing, 1904 kg (4190 lb) per shelf;

5.4.2.5 Fully configured rack units include frames, beams, and wire mesh decking;

5.4.2.6 *Beam Height*—11 cm (4⅜ in.);

5.4.2.7 *Beam Gauge*—16 ga;

5.4.2.8 *Beam Step Height*—3.8 cm (1½ in.);

5.4.2.9 *Beam Step Depth*—1.9 cm (¾ in.);

5.4.2.10 *Upright Gauge*—14 ga;

5.4.2.11 *Number of Shelves*—Two;

5.4.2.12 *Color*—Orange beams/green uprights;

5.4.2.13 *Finish*—Polyurethane rack/pre-galvanized deck; and

5.4.2.14 *Footplates*—10 cm by 11 cm (4 in. by 4¼ in.).

5.4.3 *Cart*—A typical utility cart, as shown in Fig. 3, includes one or more shelves on four wheels and is used to roll onboard materials indoors on relatively smooth floor surfaces. The example cart included in the set of standard objects in this guide includes the following specifications:

5.4.3.1 *Model*—3-Tier NSF (National Sanitation Foundation) chrome wire cart;

5.4.3.2 *Material*—Metal, chrome finish, welded wire construction;

5.4.3.3 *Dimensions*—46 cm long by 91 cm wide by 97 cm high (18 in. long by 36 in. wide by 38 in. high);

5.4.3.4 4 in. rubber swivel casters with protective doughnut bumpers;

5.4.3.5 *Capacity*—364 kg (800 lb); and

5.4.3.6 Shelves adjust in 1 in. increments.

5.4.4 *Table*—A typical table, as shown in Fig. 4, is used in offices and other workplaces. The example table included in the set of standard objects in this guide includes the following specifications:

5.4.4.1 *Model*—Steel, square tube steel legs with leveling feet and laminate top;

5.4.4.2 *Materials*—2.5 cm thick (1 in.) thick laminate top with protected PVC edges;

5.4.4.3 *Colors*—Wood grain look top, gray metal legs;

5.4.4.4 *Dimensions*—152 cm long by 76 cm wide by 97 cm high (60 in. long by 30 in. wide by 38 in. high); and

5.4.4.5 *Capacity*—33 kg (73 lb).

5.4.5 *Step Ladder*—A typical 1.8 m (6 ft) step ladder, as shown in Fig. 5, consists of repeated bars or steps (rungs) between two upright lengths of metal, wood, fiberglass, or rope, and is used for climbing up or down. The example ladder included in the set of standard objects in this guide includes the following specifications:

5.4.5.1 *Load Capacity*—113.6 kg (250 lb) Type I duty rating, ANSI Certified, OSHA Compliant;

5.4.5.2 *Open Dimensions*—106 cm spread base by 55 cm wide by 183 cm high (42 in. spread base by 21.5 in. wide by 72 in. high) standard A-frame;

5.4.5.3 *Rung/Step depth*—7.6 cm (3 in.);

5.4.5.4 *Number of Steps, Step Rise*—Six steps, 30.5 cm (12 in.);

5.4.5.5 *Folded Dimensions*—183 cm high by 55 cm wide by 15 cm deep (72 in. high by 21.5 in. wide by 6 in. deep); and

5.4.5.6 *Weight*—9.8 kg (21.5 lb).

5.4.6 *Cables or Hoses, or Both*—Cables may unsafely lie across a walkway or A-UGV path. However, this unsafe practice is not considered in this guide. A safer method is to use a cable cover that houses cables within it. Cable covers, covering floor cables for safety purposes, as shown in Fig. 6, are designed to protect cables, such as power cables and cords, from light industrial vehicles or heavy foot traffic, or both. The example cable cover included in the set of standard objects in this guide includes the following specifications:

5.4.6.1 *Material*—PVC;

5.4.6.2 *Dimensions*—64 mm wide by 11.4 mm high by 1.8 m long (2.5 in. wide by 14/32 in. high by 72 in. long);

5.4.6.3 *Color*—Black; and

5.4.6.4 Can be secured to most surfaces using double-sided tape.

5.4.7 *Chair*—A typical office chair, as shown in Fig. 7, includes a padded seat, back and arm rests, a center post, and five-spoke base on casters with adjustable height seat. The example chair included in the set of standard objects in this guide includes the following specifications:

5.4.7.1 *Model*—Office chair, ergonomic computer chair with mesh back and foam padded seat;

5.4.7.2 *Material*—Steel, iron, PP, nylon mesh, foam, non-woven fabric, and composite boards;

5.4.7.3 *Wheels*—5 pcs, 360-degree swivel;

5.4.7.4 *Color*—Black;

5.4.7.5 *Dimensions*—60 cm wide by 62 cm deep by 93 cm to 102 cm high (23.6 in. wide by 24.5 in. deep by 36.6 in. to 40.2 in. high);

5.4.7.6 *Capacity*—125 kg (275 lb);

5.4.7.7 *Adjustable Seat Height*—36.5 cm to 46.5 cm (14.4 in. to 18.3 in.);

5.4.7.8 *Seat Size*—47.5 cm long by 48.5 cm wide by 6.5 cm thick (18.7 in. long by 19 in. wide by 2.6 in. thick); and

5.4.7.9 *Weight*—9.60 kg (21.16 lb).

5.4.8 *IV Pole*—Intravenous (IV) pole is a medical device, as shown in Fig. 8, typically used to support bags of fluid or medicine that is being given to a patient. The example IV pole included in the set of standard objects in this guide includes the following specifications:

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FIG. 2 Racking

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