Designation: ~~F3327 – 18~~ F3327 – 23

Standard Practice for Recording the A-UGV Test Configuration[1]

This standard is issued under the fixed designation F3327; 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 practice describes a means to record the ~~A-UGV~~ Automatic, Automated, or Autonomous – Uncrewed Ground Vehicle (A-UGV) configuration when testing. The practice provides a method for recording A-UGV hardware and software control parameters and describes high-level capabilities, such as used for A-UGV safety and navigation.

1.2 This practice: contextualizes the A-UGV configuration during a test, including the identification and adjustment of main configuration parameters; provides the proper context for test results; provides a basis for comparison of the test circumstances across different vehicles or tests, or both; and allows a test to be recreated.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are not precise mathematical conversions to imperial units. They are close approximate equivalents for the purpose of specifying A-UGV characteristics 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.

1.4 *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.*

1.5 *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 Robotics, Automation, and Autonomous Systems

3. Terminology

3.1 Terms used within this practice refer to Terminology F3200.

4. Summary of Practice

4.1 This practice describes a method for recording the A-UGV test configuration when performing tests described in A-UGV test methods. A-UGVs have a series of hardware and software parameters that vary the vehicle functionality, for example:

[1] This practice is under the jurisdiction of ASTM Committee F45 on ~~Driverless Automatic Guided Industrial Vehicles~~Robotics, Automation, and Autonomous Systems and is the direct responsibility of Subcommittee F45.91 on Terminology.

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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.

4.1.1 Different A-UGVs may perform differently dependent upon their hardware setup and software capabilities and settings; or

4.1.2 The same A-UGV may perform differently dependent upon its hardware setup and software settings.

4.2 Main configuration parameters are, for example:

4.2.1 *Hardware*—~~Hardware:~~ A-UGV weight, size, wheelbase, drive/steer method, load carry or pull method, sensors, and onboard equipment (for example, roller tables or robot arms); and

4.2.2 *Software*—~~Software: control~~ Control and monitor software, firmware versions, and software settings for maximum accelerations and velocities, preferred paths, and restricted areas, among many other possible hardware and software configuration parameters.

4.3 *High Level Capabilities*—~~High level capabilities are, for example:~~ For example, obstacle avoidance, path planning, localization method, and safety.

4.4 This practice also contextualizes test results of a test method by identifying main configuration parameters as requested prior to the test method. A-UGV configuration is reported using a standard method, defined in this practice, which includes the documentation of the context for test results. For example, the result of a timed test could be dependent upon varying speed ~~constraints – an~~constraints: an A-UGV having a speed constraint of 1.5 m/s as compared to a speed constraint of 2.0 m/s. As such, comparing two A-UGV configurations could allude to which parameters affect vehicle performance.

5. Significance and Use

5.1 The significance of the information to be recorded in a test report allows for A-UGV performance to be contextualized with A-UGV configuration.

5.2 Limitations of the practice are that not all A-UGVs have the same capabilities or configuration parameters. For example, for capabilities, a vehicle that remaps during navigation versus another vehicle that uses a static map may behave differently in repeated runs of an obstacle avoidance test. For configuration, a vehicle that remaps during navigation may have varying times that obstacles remain in the map for test recreation.

5.3 The environment map used by the A-UGV, developed through localization including any landmarks, shall be saved as used on the A-UGV and should be saved and provided as a human-readable layout on or off the A-UGV (see Appendix X1 showing a sample layout drawing).

5.4 The main A-UGV hardware parameters shall be recorded as follows:

5.4.1 Make and ~~Model~~model;

5.4.2 Part ~~Number~~number;

5.4.3 Serial ~~Number~~number;

5.4.4 Hardware ~~Revision~~revision number (if ~~any)~~any);

5.4.5 Number of drive/steer ~~wheels~~wheels;

5.4.6 Steering ~~type~~type;

5.4.7 ~~Type: for example, Fork, Tugger, Unit Load, Cart~~A-UGV Type—For example, fork, tugger, unit load, cart; and

5.4.8 ~~Loaded/Unloaded~~Loaded/unloaded.

5.5 The main A-UGV software parameters shall be recorded as follows:

5.5.1 All applicable software and firmware ~~versions.~~versions;

5.5.2 *Velocity—*~~Velocity – translation~~Translation and rotation, ~~minimum/maximum.~~minimum/maximum;

5.5.3 *Acceleration—*~~Acceleration – translation~~Translation and rotation, ~~minimum/maximum.~~minimum/maximum; and

5.5.4 *Stand-off Distances—*~~Stand-off distances – safety~~ Safety sensor thresholds, obstacle avoidance thresholds.

5.6 The context for the test shall be recorded by providing detailed answers to the following questions:

5.6.1 When are the various software configurations used during the test? For example, two software versions may be required as follows: Use configuration A for straight aisles and configuration B for turns.

5.6.2 What other hardware and software parameters/settings are required to recreate the A-UGV behavior (that is, attached debug, settings, or other files)?

5.6.3 What is the A-UGV layout that is saved and used on the vehicle and, if possible, saved and provided as a human-readable version?

5.6.4 Are there constraints that the requestor has placed on the A-UGV? Examples may include the following:

5.6.4.1 *Generic Test Environment—*~~generic test environment: for~~ For example, outdoors or indoors, day or night, defined or undefined test areas?

5.6.4.2 ~~velocity~~Velocity and acceleration that are below the maximum capability?

5.6.4.3 ~~clearances~~Clearances between the A-UGV and an obstacle during obstacle avoidance maneuvering?

5.6.4.4 ~~negative~~Negative obstacle measurement capability enabled?

5.6.4.5 ~~choose~~Choose its own path or is required to use a preferred path?

5.7 Higher-level categories of A-UGV capabilities shall be recorded as follows:

5.7.1 *Localization Method—*~~Localization method: for~~ For example, natural features, reflective markers, tape on ground, matrix barcodes/visual fiducial system, lights in ceiling.

5.7.2 *Safety-rated Equipment—*~~Safety-rated equipment: for~~ For example, scanning lasers and their make and model numbers; other functions of safety sensors.

5.7.3 *Other Sensors Used—*~~Other sensors used: for~~ For example, cameras, including their make and model numbers, and image processing software used for path planning.

5.7.4 *Added Equipment for A-UGV Testing—*~~Added equipment for A-UGV testing: for~~ For example, cameras, including their make and model numbers, and image processing software used for capturing docking performance.

6. Procedure

6.1 When conducting the Committee F45 test methods, the test requestor can choose the A-UGV configuration to be recorded as described in Section 4. The test requestor can elect and apply any of the configuration methods and parameters to the A-UGV-under-test included herein and record the levels as described in Section 7.

6.2 A-UGV configuration may be changed prior to a test. At any time after the start of a test, as instructed by the test supervisor, the A-UGV configuration shall not be manually changed by any person. In the event that the A-UGV configuration automatically changes during a test, the test requestor shall inform the test supervisor of such occurrence(s) prior to the test and the occurrence(s) shall be noted on the test report.

7. Report

7.1 A test report is required for recording the A-UGV configuration. The test report shall include the following features:

7.1.1 A photograph or detailed drawing showing the hardware configuration of the A-UGV to be ~~tested.~~tested;

7.1.2 A hardcopy or electronic file of the software configuration of the A-UGV to be ~~tested.~~tested; and

7.1.3 Any additional A-UGV features or important notes, or both, that may cause A-UGV performance variation.

7.1.4 The test report (see example in Fig. X1.1) shall be filled out. In the situation where a particular configuration parameter is not known, it shall be noted as such using "Unknown."

NOTE 1—The implementation of a test report is not standardized. As such, the resulting test reports can be different while conforming to this specification. Fig. 1 provides an illustration of a blank test report for this practice.

8. Keywords

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

Standard Test Methods For Automatic, Automated, and Autonomous Unmanned Ground Vehicles (A-UGVs)

ASTM International Committee F45 on Robotics, Automation, and Autonomous Systems

STATUS: ASTM F3327 Version: 10

Standard Practice for Recording the A-UGV Test Configuration

DIMENSIONED AND LABELED DRAWING OF TEST METHOD APPARATUS:

(mark and label start and docking locations, fiducial mounting locations, and locations of all additional objects, markers, reflectors, sensors, etc.)

TEST TECHNICIAN: _____

(a)

FIG. 1 Test Report: (*a*) Drawing and (*b*) Parameters Table

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Standard Practice for Recording the A-UGV Test Configuration

Fill in the table as described in sections 5 and 6. When no information is available for a parameter, leave blank. Attach additional pages as needed.

The main A-UGV hardware parameters		
	Make and Model	
	Part Number	
	Serial Number	
	Hardware Revision number (if any)	
	Number of drive/steer wheels	
	Steering type	
	Type	
	Loaded/Unloaded	
	Hardware Revision number (if any)	
The main A-UGV software parameters		
	All applicable software and firmware versions	
	Velocity	
	Acceleration	
	Stand-off distances	
The context for the test is recorded by providing detailed answers to the following questions:		
	When are the various software configurations used during the test?	
	What other hardware and software parameters/settings are required to recreate A-UGV behavior (i.e., attached debug, settings, or other file)	
	What is the A-UGV layout that is saved and used on the vehicle and, if possible, saved and provided as a human-readable version?	
	Are there constraints that the requestor has placed on the **A-UGV**?	
Higher-level categories of A-UGV capabilities are recorded as follows:		
	Localization method	
	Safety-rated equipment	
	Other sensors used	
	Added equipment for vehicle testing	

TEST TECHNICIAN: _____

(b)

FIG. 1 Test Report: (*a*) Drawing and (*b*) Parameters Table *(continued)*

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLE A-UGV CONFIGURATION – AUTOMATIC - UGV

X1.1 An example Automatic-UGV was used to verify the practice of recording the A-UGV configuration as described in this practice. Fig. X1.1 shows the completed Test Report for the example Automatic-UGV.

X1.2 Example Detailed Software Parameters

X1.2.1 The following are screenshots of main and detailed software parameters set for an Automatic-UGV. Although the method for describing the detailed software parameters is not a part of this practice, the user should provide this and any other information about the A-UGV configuration so that the manufacturer or user can replicate tests of this vehicle. Figs. X1.2-X1.7 provide examples of additional software information.

Standard Test Methods For Automatic, Automated, and Autonomous Unmanned Ground Vehicles (A-UGVs)

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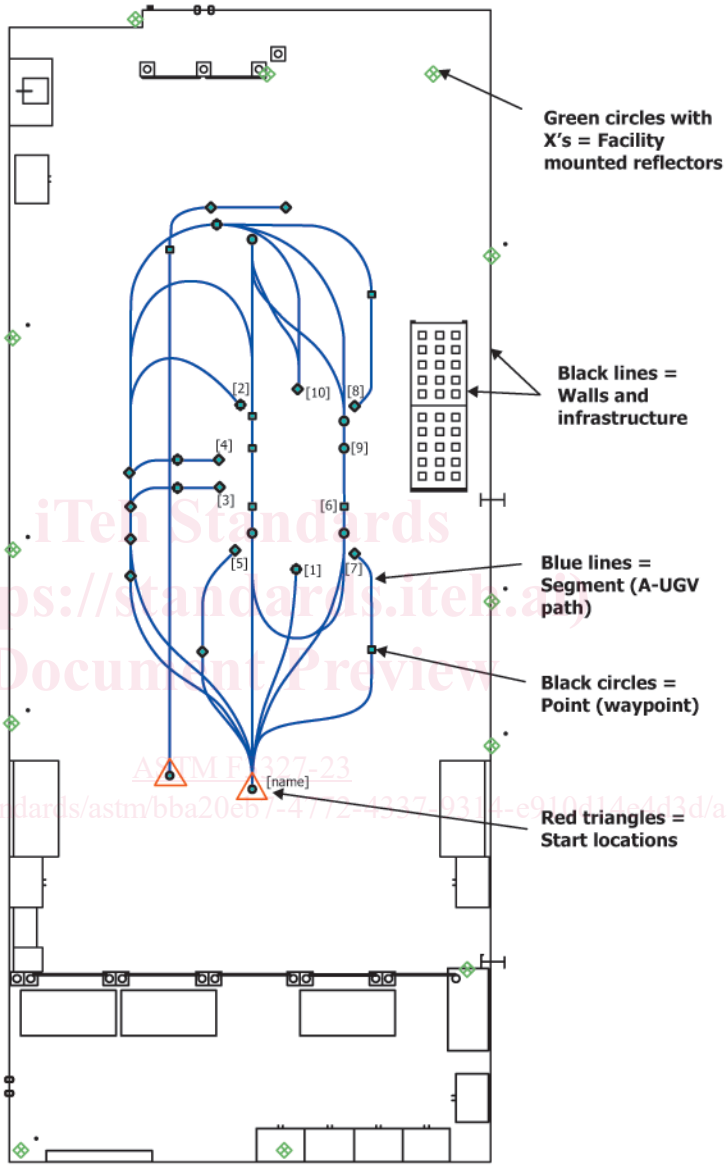
Standard Practice for Recording the A-UGV Test Configuration

DIMENSIONED AND LABELED DRAWING OF TEST METHOD APPARATUS:

(mark and label start and docking locations, fiducial mounting locations, and locations of all additional objects, markers, reflectors, sensors, etc.)



TEST TECHNICIAN: Roger Brooks

(a)

FIG. X1.1 Example Test Report for an Automatic-UGV

Standard Test Methods For Automatic, Automated, and Autonomous Unmanned Ground Vehicles (A-UGVs)

ASTM International Committee F45 on Robotics, Automation, and Autonomous Systems

STATUS: ASTM WK60974 Version: 10

Standard Practice for Recording the A-UGV Test Configuration

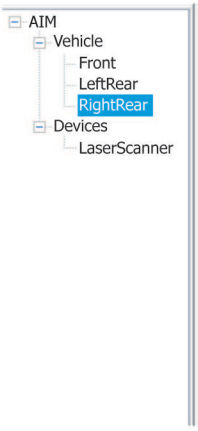
Fill in the table as described in sections 5 and 6. When no information is available for a parameter, leave blank. Attach additional pages as needed.

The main A-UGV hardware parameters		
	Make and Model	AIM AGV
	Part Number	1
	Serial Number	1
	Hardware Revision number (if any)	
	Number of drive/steer wheels	3
	Steering type	quad
	Type	fork
	Loaded/Unloaded	unloaded
The main A-UGV software parameters		
	All applicable software and firmware versions	1
	Velocity	1 m/s
	Acceleration	
	Stand-off distances	0.5 m min
The context for the test is recorded by providing detailed answers to the following questions:		
	When are the various software configurations used during the test?	throughout test
	What other hardware and software parameters/settings are required to recreate A-UGV behavior	
	What is the A-UGV layout that is saved and used on the vehicle and, if possible, saved and provided as a human-readable version?	point and segment map
	Are there constraints that the requestor has placed on the **A-UGV**?	no
Higher-level categories of A-UGV capabilities are recorded as follows:		
	Localization method	spinning laser - range/azimuth
	Safety-rated equipment	three, 2D safety laser scanners
	Other sensors used	
	Added equipment for vehicle testing	

TEST TECHNICIAN: Roger Brooks

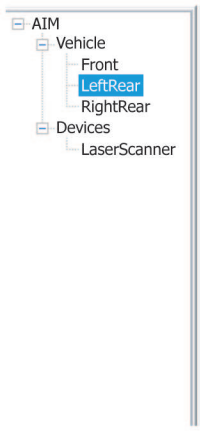
(b)

FIG. X1.1 Example Test Report for an Automatic-UGV *(continued)*



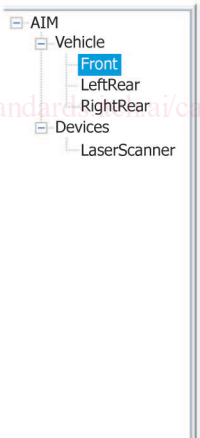
Info	Parameter	Value	Unit
	MaxAngularSpeed	90	deg/s
	MinSteerAngle	-110	deg
	MaxSteerAngle	110	deg
	X	-727	mm
	Y	-259	mm
	SetSpeedRef	SDIO_2.SetSpeed	
	SetAngleRef	SDIO_2.SetAngle	
	SetSpeedEnableRef	SDIO_2.DriveEnable	
	SetAngleEnableRef	SDIO_2.SteerEnable	
	EncSpeedRef	SDIO_2.Enc2Speed	
	EncDistRef	SDIO_2.Enc2Dist	
	EncAngleRef	SDIO_2.Enc1Angle	
	EncSpeedPlcInputRef	NotUsed	
	EncAnglePlcInputRef	NotUsed	
	WheelType	SD	
	PlcSetAngle	0	cdeg
	PlcSetSpeed	0	mm/s
Properties			

(a)



Info	Parameter	Value	Unit
	MaxAngularSpeed	90	deg/s
	MinSteerAngle	-110	deg
	MaxSteerAngle	110	deg
	X	-727	mm
	Y	259	mm
	SetSpeedRef	SDIO_1.SetSpeed	
	SetAngleRef	SDIO_1.SetAngle	
	SetSpeedEnableRef	SDIO_1.DriveEnable	
	SetAngleEnableRef	SDIO_1.SteerEnable	
	EncSpeedRef	SDIO_1.Enc2Speed	
	EncDistRef	SDIO_1.Enc2Dist	
	EncAngleRef	SDIO_1.Enc1Angle	
	EncSpeedPlcInputRef	NotUsed	
	EncAnglePlcInputRef	NotUsed	
	WheelType	SD	
	PlcSetAngle	0	cdeg
	PlcSetSpeed	0	mm/s
Properties			

(b)



Info	Parameter	Value	Unit
	MaxAngularSpeed	90	deg/s
	MinSteerAngle	-110	deg
	MaxSteerAngle	110	deg
	X	727	mm
	Y	0	mm
	SetSpeedRef	SDIO.SetSpeed	
	SetAngleRef	SDIO.SetAngle	
	SetSpeedEnableRef	SDIO.DriveEnable	
	SetAngleEnableRef	SDIO.SteerEnable	
	EncSpeedRef	SDIO.Enc2Speed	
	EncDistRef	SDIO.Enc2Dist	
	EncAngleRef	SDIO.Enc1Angle	
	EncSpeedPlcInputRef	NotUsed	
	EncAnglePlcInputRef	NotUsed	
	WheelType	SD	
	PlcSetAngle	0	cdeg
	PlcSetSpeed	0	mm/s
Properties			
	Type	WheelSD	
	Name	Front	

(c)

All wheels are driven and steerable for this vehicle. Values are changeable.

FIG. X1.2 Software Parameters Set for the (*a*) Right Rear, (*b*) Left Rear, and (*c*) Front ~~Wheels. All Wheels are Driven and Steerable for this Vehicle. Values are Changeable~~Wheels