ASTM Committee F45
9th Bi-Annual Meeting

Roger Bostelman
Chairman, ASTM Committee F45
NIST

Karen Murphy
ASTM F45 Staff Manager

April 30-May 1, 2019
Lowell, MA

Agenda
Day 1

Tuesday, Apr 30	UMass Lowell NERVE Center	
Start	**Event**	**Lead**
8:00 AM	Greetings, Introductions, Agenda	Bostelman
8:10 AM	UMass Lowell Greeting and Presentation	UML, Norton
8:30 AM	F45.90 Executive Committee meeting - history overview, status, officers, ASTM information, etc.	Bostelman, Murphy
9:00 AM	F45.01 Environmental Conditions	Bostelman
9:30 AM	Coffee Break	
9:45 AM	F45.91 Terminology - A-UGV Capability Levels	Bostelman
11:45 AM	**Lunch**	
12:45 PM	F45.02 - Navigation and Docking	Roberts
2:45 PM	Coffee Break	
3:00 PM	Day 1 wrap-up and next day agenda	Bostelman, Norton
3:15 PM	Demonstrations: Vehicle capabilities, environmental conditions, docking, navigation, obstacles... (communication impairment?)	Norton
4:45 PM	Adjourn	
6:00 PM	Dinner - The Keep	

Agenda
Day 2

Wednesday, May 1		UMass Lowell NERVE Center	
Start		**Event**	**Lead**
8:00 AM	*0:15:00*	Day 2 agenda review, logistics, etc.	Bostelman
8:15 AM	*2:00:00*	F45-03 Object Detection & Protection - Describing Obstacles (Static and Dynamic)	Norton
10:15 AM	*0:15:00*	Coffee Break	
10:30 AM	*2:00:00*	F45-04 Communication & Integration - Comm. Impairment	Holmberg
12:30 PM	*0:30:00*	**Lunch**	
1:00 PM	*0:30:00*	Fleets	Reynolds
1:30 PM	*2:00:00*	Building block standards	Norton
3:30 PM	*0:15:00*	Coffee Break	
3:45 PM	*0:30:00*	Main Committee - Subcommittee Reports, Future works	Bostelman
4:15 PM		Adjourn	
4:00 PM to 5:20 PM	*1:15:00*	ASTM interviews and video recording	LaFary, Roberts, Norton, Bostelman
6:00 PM		Dinner - Lowell Burger Co.	

Dinners

- Monday Fuse Bistro, 10 minute walk
- Tuesday The Keep, 10 minute walk
- Wednesday Lowell Burger Co.

		10	17	10
Name	**Affiliation**	**Monday dinner**	**Tuesday dinner**	**Wednesday dinner**
Bostelman, Roger	NIST	yes	yes	yes
Ferman, Ahmet M	Omron Adept Technologies		yes	yes
Gates, Rusty	Universal Parks and Resorts		yes	yes
Ghataore, Gurpreet	The Manufacturing Technology Centre		yes	yes
Holmberg, Robert	Google	yes	yes	
Jordan, Adam	The Manufacturing Technology Centre		yes	yes
LaFary, Matt		yes	yes	yes
Li, Qiang	Shenzhen Click Technology			
Marino, Anthony	SOSV HAX			
Messina, Elena	NIST	yes	yes	
Murphy, Karen	ASTM International	yes	yes	yes
Noelte, Greg	Sensata Technologies		yes	
Norton, Adam	University of Massachusetts Lowell	yes	yes	yes
Pedersen, Christian Have	Mobile Industrial Robots	yes	yes	
Reynolds, Todd	Omron Adept Technologies		yes	yes
Roberts, Malcolm T	BR2 Consulting			
Sarbak, Emre	Mediate			
Sparrow, Mary Ellen T	Next Shift Robotics			
Vogtman, Randall	Oceaneering International, Inc		yes	
Yanco, Holly	University of Massachusetts Lowell	yes	yes	
Davis, Chris	ASTM International	yes	yes	
Huang, Ahing	ASTM International	yes	yes	yes

Introductions

- Name
- Organization and your role
- F45 Member or Guest?

Welcome and Overview
University of Massachusetts Lowell

- **Julie Chen**, Vice Chancellor for Research and Innovation
- **Adam Norton**, NERVE Center Assistant Director
  New England Robotics Validation and Experimentation

F45.90 Executive Subcommittee Meeting

Roger Bostelman
Chairman, ASTM Committee F45

Karen Murphy
ASTM Staff Manager

April 30, 2019

Committee Officers & ASTM Staff

F45 CHAIRMAN	Bostelman, Roger	
F45 VICE-CHAIRMAN	LaFary, Mathew	
F45 SECRETARY	Norton, Adam	
F45 MEMBERSHIP SECRETARY	LaFary, Mathew	
F45.01 SUB-CHAIRMAN	Bostelman, Roger	Environmental Effects
F45.02 SUB-CHAIRMAN	Roberts, Malcolm	Navigation and Docking
F45.03 SUB-CHAIRMAN	Norton, Adam	Obstacle Detection and Protection
F45.04 SUB-CHAIRMAN	Holmberg, Bob	Communication and Integration
F45.91 SUB-CHAIRMAN	Bostelman, Roger	Terminology
ASTM STAFF MANAGER	Murphy, Karen	
ASTM ADMIN ASSISTANT	McKeever, Marianne	
ASTM EDITOR	Rosborough, Mark	

Membership/Attendees

Committee	July 2018	Dec 2018
F45	49	51
F45.01	22	27
F45.02	35	39
F45.03	41	45
F45.04	36	40
F45.91	27	32

Classification	Dec 2018
Producer	21
User	8
General Interest	22

Countries
Canada
China
Finland
India
Japan
Russia
Singapore
Sweden
Switzerland
UK
USA

Key Roles to fill

- F45.01 Chairman – Environmental Effects

Recent New Members

- Ockwoo Nam, Korean Intellectual Property Office

- Constantine Panagotacos, Dunn Panagotacos Attorneys at Law

ASTM F45 Committee Accomplishments

Eight (8) Bi-Annual Face-to-Face Meetings

- And at least once per year, these meetings also hold demonstrations of standards being developed.

Two Workshops

- First Workshop – at IEEE ICRA 2015
  - Ten (10) papers were presented and discussions followed
  - Published ASTM book - STP1594 “Autonomous Industrial Vehicles: From the Laboratory to the Factory Floor”
- Second Workshop – with July 2018 meeting
  - Developed new work items:
    - A-UGV Capabilities (and a *roadmap to future standards development*)
    - Combining A-UGV Standards (e.g., navigation, docking, obstacles, communication impairments, etc.)

ASTM Awards

- Robert J. Painter Memorial Award
- James A. Thomas President's Leadership Award
- Two (2) Awards for Outstanding F45 Participation

NIST Website

- https://www.nist.gov/el/intelligent-systems-division-73500/unmanned-ground-vehicles-research-and-standard-test-methods

ASTM F45 Meeting #8 Annecy, France hosted by Omron

ASTM F45 Committee Accomplishments

Standards and Work Items

- Published standards
  1. F3200-17,18 Terminology for Driverless Automatic Guided Industrial Vehicles
  2. F3218-17 Standard Practice for Recording Environmental Effects for Utilization with A-UGV Test Methods
  3. F3244-17 Standard Test Method for Navigation: Defined Area
  4. F3265-17 Standard Test Method for Grid-Video Obstacle Measurement
  5. F3327-18 Standard Practice for Recording the A-UGV Test Configuration
- Work Items
  1. F45.01 - WK54576 Standard Practice for Recording Environmental Conditions for Utilization with A-UGV Test Methods
  2. F45.02 - WK57000 Standard Test Method for Docking Driverless Automatic Guided Industrial Vehicles
  3. F45.02 - WK65141 Standard Guide for Combining A-UGV Standards
  4. F45.03 - WK54662 Standard Practice for Capturing A-UGV Positions using Grid-Video Techniques
  5. F45.03 - WK60390 Standard Practice for Describing Stationary Obstacles Utilized within A-UGV Test Methods
  6. F45.04 - WK54431 Standard Practice for Implementing Communications Impairments on A-UGV Systems
  7. F45.91 - WK65139 Standard Guide for A-UGV Capabilities

Recent Ballots

Obstacles

Ballot	Issue Date	Closing Date
F45 (19-01)	Mar 07, 2019	Apr 16, 2019

2018/2019 Ballots

Obstacles

Env Cond.

Test Config.

Letter Ballot	Issue Date	Closing Report Posted
F45.03 (19-01)	January 14, 2019	February 14, 2019
F45 (18-03)	November 14, 2018	December 17, 2018
F45 (18-02)	May 11, 2018	June 18, 2018

Minimal votes … *again*

COMMITTEE OFFICERS:

CHAIRMAN		Roger Bostelman
SECRETARY		Adam Norton
SUBCHAIRMAN	(0300)	Adam Norton

BALLOT STATISTICS:

Committee	Sent	Returned	% Returned
F45	43	26	60.46

Item	Sub	Action		Committee	AFF	NEG	ABST	PCNT
001	03	NEW STANDARD Practice for Describing Stationary Obstacles Utilized within A-UGV Test Methods		F45	18.00	1.00	7.00	94.73
		TECHNICAL CONTACT: Adam Norton						
		WORK ITEM: WK60390						

Negative Voters:

Hui-Min Huang

Comments:

Robert Holmberg

Inactivity Report

Committee	Affiliation/Contact	Consecutive Ballots Not Returned	Designation of Last Missed Ballots	Response from Voter
Emanuel, David	1776007 Amerden Inc United States 302.463.6134 david.emanuel@dcemanuel.com	4	(18-03) (18-02) (18-01) (17-02)	No Response
Auguste, Carlet	2031285 United Technologies Aerospace Systems United States 779.348.4327 Carlet.Auguste@utas.utc.com	3	(18-03) (18-02) (18-01)	No Response
Schwartz, Justin M	000423520 Universal Studios Orlando United States 407.224.3049 justin.schwartz@nbcuni.com	3	(18-03) (18-02) (18-01)	No Response
Wysowaty, Walter	2041701 WMW Forensics United States 190.879.7551 walt@wmwforensics.com	3	(18-03) (18-02) (18-01)	No Response

F45.90 Admin.

Voting Inactivity

- A member was inactive for 5 ballots
- Possible mismatch in ASTM alerts
  - This org. has three members – one voting and one redundant-non-voting – the inactive member is *not* the voting member for the organization
  - i.e., why the alert?

  More important for F45 Exec: need policy for how to handle more than X missed votes
  - Alerts are sent by ASTM for missed votes
  - Suggested policy: warning from the Exec Comm. after 3 missed votes that they'll be removed as a voting member if another vote is missed – can still participate in F45.

- What else can be done to get votes?
  - Continuous emails to members?

Ballots

- Pixelated images on ASTM ballot postings.

Upcoming Meetings

- Monthly E-meetings:
  - F45.02 1st Tuesday /month 1-3 PM ET
  - F45.03 2nd Tuesday /month 1-3 PM ET
  - F45.04 3rd Tuesday /month 1-3 PM ET
  - F45.91/.01 4th Tuesday /month 1-3 PM ET

- Face-to-Face Meeting
  - 10th Bi-Annual Face-to-Face Meeting:
    - Where ?
    - When: Fall 2019
  - 11th Bi-Annual Face-to-Face Meeting:
    - Where ?
    - When: Spring 2020

F45.01 Environmental Effects Subcommittee Meeting

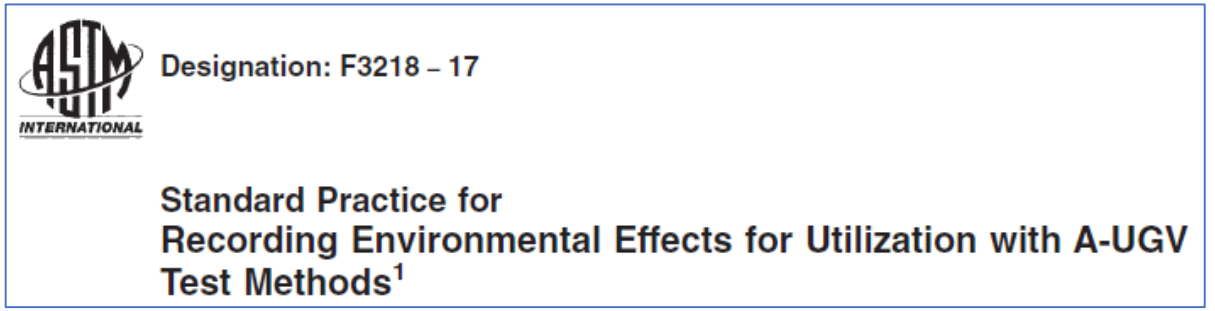
Roger Bostelman

Chairman, ASTM F45.01

April 30, 2019

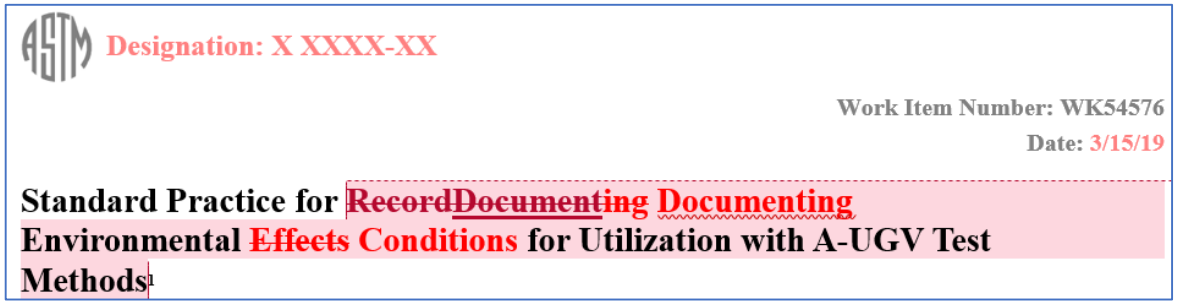
F45.01 Agenda

- Old business
  - Modifying WK54576 Standard Practice for Recording Environmental ~~Effects~~ Conditions for Utilization with A-UGV Test Methods
    - Added test method references, boundaries, etc.
    - Ballot F45 (18-03) – closed 14 Dec 2018
    - One negative and some comments
- New business
  - Review document prior to pre-ballot/ballot
    - 4. Significance and Use; Gap/Step; etc.
    - Needs updated test reports



Designation: F3218 – 17

Standard Practice for
Recording Environmental Effects for Utilization with A-UGV Test Methods[1]



Designation: X XXXX-XX

Work Item Number: WK54576
Date: 3/15/19

Standard Practice for ~~Record~~~~Documenting~~ Documenting Environmental ~~Effects~~ Conditions for Utilization with A-UGV Test Methods[1]

UMASS LOWELL
NERVE CENTER

Demonstrations

Adam Norton, NERVE Center Assistant Director

New England Robotics Validation and Experimentation

F45.91 Terminology Subcommittee Meeting

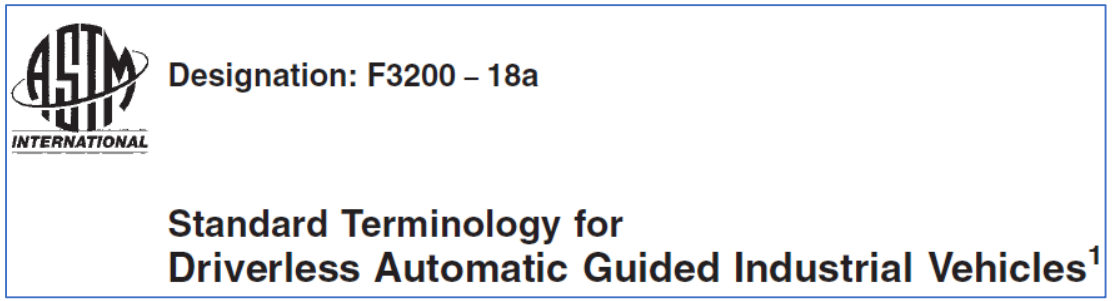
Roger Bostelman

Chairman, ASTM F45.91

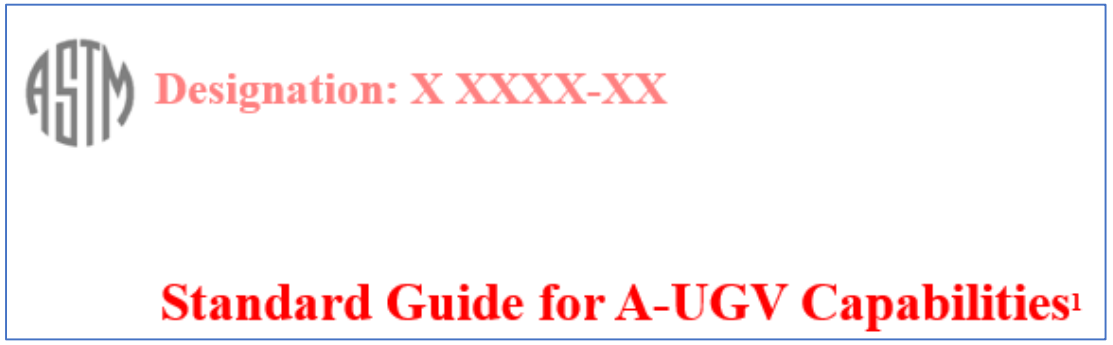
April 30, 2019

F45.91 Agenda

- Old business
  - No WK65139 A-UGV Capabilities
    - Developed *navigation* and *docking* capabilities



- New business
  - Are there other terms from other standards to add to F3200?
  - WK65139 A-UGV Capabilities
    - Several proposed terms
    - Discuss table of A-UGV Capabilities



Old Business

	A-UGV CAPABILITY			
CLASSIFIER	**3**	**4**	**5**	**6**
Navigation	Follows preprogrammed path	Leaves preprogrammed path and returns to preprogrammed path	Can find an alternate preprogrammed path	Self-routes to the goal
- infrastructure dependence	relies on infrastructure	relies on infrastructure	relies on infrastructure	relies on infrastructure
	does not rely on infrastructure; corrects for errors	does not rely on infrastructure; corrects for errors	does not rely on infrastructure; corrects for errors	does not rely on infrastructure; corrects for errors
Docking	Docks at preprogrammed waypoints	Able to adjust based on local docking position	Dynamic docking with moving objects	
- infrastructure dependence	relies on infrastructure	relies on infrastructure	relies on infrastructure	
	does not rely on infrastructure; corrects for errors	does not rely on infrastructure; corrects for errors	does not rely on infrastructure; corrects for errors	
- docking degrees of freedom	x (heading)	x (heading)	x (heading)	
	y (side-to-side)	y (side-to-side)	y (side-to-side)	
	z (vertical)	z (vertical)	z (vertical)	
	roll (rot. about x)	roll (rot. about x)	roll (rot. about x)	
	pitch (rot. about y)	pitch (rot. about y)	pitch (rot. about y)	
	yaw (rot. about z)	yaw (rot. about z)	yaw (rot. about z)	

New Business: A-UGV Capabilities

CLASSIFIER	A-UGV CAPABILITY					
Goal Navigation: Pre-Programmed	Can navigate a preprogrammed path to the goal.	If encounters obstacle, can leave the preprogrammed path and return to the preprogrammed path to the goal	If blocked, can navigate an alternate preprogrammed path to the goal. E.g., navigate a different hallway/aisle	If blocked, can navigate multiple alternate preprogrammed paths to the goal. E.g., navigate a third hallway/aisle if the second is blocked		
Goal Navigation: In situ	Can determine and navigate an initial path to the goal	If blocked, can determine and navigate an alternate path to the goal. E.g., navigate a different hallway/aisle	If blocked, can determine and navigate multiple alternate paths to the goal. E.g., navigate a third hallway/aisle if the second is blocked			
- infrastructure dependence - ability to rely on ~~physical~~ features in the environment	Can rely on features in the environment that were specifically installed to assist A-UGV operation. E.g., magnetic tape, QR codes	Can rely on natural features. E.g., walls, racking	~~Can operate without reliance on infrastructure. E.g., GPS?~~			
Localization	A-UGV can find it's initial pose automatically.	Given an initial pose, A-UGV doesn't get lost in a static environment e.g., office building	Given an initial pose, A-UGV doesn't get lost in a dynamic environment e.g., warehouse with pallets being moved	Given that the A-UGV is correctly localized, it [becomes forcably unlocalized] gets picked up and moved to another location (kidnapped), then it stops and requires human intervention to restart	A-UGV can automatically determine its pose after being kidnapped.	A-UGV can update it's environment map based on detected changes in the environment (e.g., continuous SLAM)
Docking	Can position at preprogrammed waypoints, E.g,, absolute coordinates	Can dock with a static object, E.g., conveyer	Can dock with a moveable but, stationary object, E.g., another vehicle, pallet or cart	coordinated movement E.g., mid-air fueling		

New Business: A-UGV Capabilities

Environmental conditions under which the A-UGV can operate	Mobility: Refer to ASTM F3218-18, section 4.9 Ground Surface for: elevation change up/down; gap; grade; deformability; undulation; floor particulates; coefficient of friction; boundaries (e.g., cold storage curtains)	IP Rating: refer to IP Rating scale, e.g., EN 60529 (British BS EN 60529:1992, European IEC 60509:1989)	list the env cond categories			
Obstacle Avoidance - Single Vehicle	Can stop when path is obstructed. E.g., pallet in the path.	Can navigate around static obstacles without collision. E.g., navigating around a box partially blocking a hallway	Can navigate around moving obstacles without collision. E.g., navigating around a moving vehicle that crosses the A-UGV path			
Types of objects that can be avoided and are within the A-UGV envelope	on ground, < 10 cm obstacle height	on ground, 10 to 20 cm obstacle height	on ground, > 20 cm obstacle height	elevated >= 20 cm and within the A-UGV envelope, < 10 cm obstacle height	elevated >= 20 cm and with the A-UGV envelope, >= 10 cm obstacle height	
Types of objects that can be avoided and are outside of the A-UGV envelope	negative obstacles, <= 1 cm obstacle height, E.g., missing tile	negative obstacles, > 1 to <= 10 cm obstacle height, E.g., removable panel on a raised floor	negative obstacles, > 10 cm obstacle height, E.g., loading dock, cliff, manhole	elevated above the A-UGV envelope and within the vertical projection of the A-UGV envelope	beside the A-UGV envelope	
Information Sharing/Updating (e.g., presence of obstacles, environment map changes)	one A-UGV information is shared with one or more A-UGVs in its fleet from the same manufacturer	one A-UGVs information is shared with its fleet from different manufacturers	Information from a sensor connected to the A-UGV System informs its fleet from the same manufacturer	Information from a sensor connected to the A-UGVS informs its fleet from different manufacturers	External systems can inform the fleet	

New Business: A-UGV Capabilities

Fleet Navigation Coordination	Stop and wait for permission to use a traffic zone (one A-UGV per traffic zone)	Gets permission to use a traffic zone without requiring stopping (one A-UGV per traffic zone)	Stop and wait for permission to use a traffic zone (more than one A-UGV per traffic zone)	Gets permission to use a traffic zone without requiring stopping (more than one A-UGV per traffic zone)	Doesn't require traffic zones, requires communication with fleet controller and/or other vehicles	Doesn't require traffic zones, without requiring communication with fleet controller and/or other vehicles		define zone
Fleet Makeup	Homogenous A-UGVs	Heterogenous A-UGVs, same manufacturer	Heterogenous A-UGVs, different manufacturer					
Fleet Task Assignment	manual task assignment - give each A-UGV it's own task	automatic task assignment - give fleet controller tasks to be performed by the A-UGVs						
Fleet Task Coordination	tasks can only be given when they are able to be executed	can give future time that task needs to occur	tasks are performed by one A-UGV but can only be performed by a subset of the fleet	tasks can require collaboration of multiple A-UGVs	can reorder execution of tasks when given new tasks	tasks can have priority	can change A-UGV performance based on predicted future tasks	tasks can have dependencies of other tasks

Impaired Communication Behavior	When communication is impaired, A-UGV stops and when communication resumes, requires human intervention in order to restart normal operation	When communication is impaired, A-UGV stops and when communication resumes, does not require human intervention in order to restart normal operation	While communication is impaired, A-UGV has modified operation, E.g., drive slower	While communication is impaired, continues normal operation
Lost Communication Behavior	When communication is lost, A-UGV stops and when communication resumes, requires human intervention in order to restart normal operation	When communication is lost, A-UGV stops and when communication resumes, does not require human intervention in order to restart normal operation	While communication is lost, A-UGV has modified operation, E.g., drive slower	While communication is lost, continues normal operation

New Business

F45 Terminology for e.g., A-UGV Capabilities

Red – existing F45.91 term/def

Blue – suggested changes

infrastructure – the immovable parts and features of the facility (e.g., walls, hills, doorways, navigation reflectors)

object, n—anything in the environment that ~~may or may not be an obstacle. [ASTM F3200-18]~~ is not infrastructure

obstacle, n—static or moving object ~~or feature~~ that obstructs the intended movement. [ASTM F3200-18]

~~guidepath, n—intended path for an A-UGV used with automatic or automated guidance. [ASTM F3200-18]~~

~~intended~~ **path**, n—~~heading~~ trajectory of a vehicle at a given instant in time dictated by the control logic, recognizing that the ~~heading~~ trajectory is a dynamic property and can change at any instant in time depending on conditions in the operating environment (for example, the decision to allow a vehicle to pass another vehicle or to navigate around an obstacle); ~~see path deviation, guidepath. [ANSI/ITSDF B56.5] [ASTM F3200-18]~~

zone – predefined control area for coordinating A-UGV movement (e.g., traffic zones)

navigation aids - features in the environment that were specifically installed to assist in A-UGV navigation (e.g., guide tape, reflectors)

> natural features, n—features in the environment that were not specifically installed to assist in A-UGV navigation. [ASTM F3200-18]

fleet – collection of vehicles coordinated to perform a function

contour area –

A-UGV envelope - A-UGV contour area + clearance

delete ~~***local operator***~~

New Business - meeting objectives

- Review terms/definitions to be used in the capabilities guide
- A-UGV Capabilities
  - Review capabilities spreadsheet – informally approve
  - Continue drafting the standard guide

Subcomm. Notes

.03

- WK60390 Practice for Describing Static Obstacles
  - Negative - Hui
  - 60% return, 66% sub, 90% main votes, all can vote regardless of status
- WK68031 Practice for Describing Moving Obstacles
  - Rigid: Doors – swing, garage,
  - Soft: Curtains

.04

- Roger - work with Bob H. to modify Fig 1:
  - add traffic control and cloud
  - add a new measurement figure showing the actual connections with the measurement device.

F45 Main Meeting

Roger Bostelman
Chairman, ASTM Committee F45

Karen Murphy
ASTM Staff Manager

April 30, 2019

Main Agenda

- Subcommittee reports - priorities
- F45 Main Officers – 2 yr timeframe, 3 terms in a row
  - Nominated same Main officers through motion, 2nd
  - Karen will send nomination ballot around October for anyone else to become a Main Officer should they choose.
- F45 Promotion/Inform SDOs
- Next Meetings

Promoting F45

- Joint Standards
  - ITSDF B56.5 Driverless Automatic Guided Industrial Vehicle Safety
    - Roger presented F45 update at the February 2019 meeting, Sarasota, FL
  - MHIA requested F45 update for their AGV Focused meeting
  - Old Business:
    - RIA 15.08 Mobile Robot and Mobile Manipulator Safety
      - Roger presented F45, October 2018 meeting at NIST towards harmonization of terminology
- Video
  - work with editors to produce F45 promotion video
- Future Meetings
  - International (most members from USA) - promoting F45 face-to-face is ideal
  - Demonstrations and/or real A-UGV installations to observe - also ideal

Upcoming Meetings

- Monthly E-meetings:
  - F45.02 1st Tuesday /month 1-3 PM ET
  - F45.03 2nd Tuesday /month 1-3 PM ET
  - F45.04 3rd Tuesday /month 1-3 PM ET
  - F45.91/.01 4th Tuesday /month 1-3 PM ET

- Face-to-Face Meeting
  - 10th Bi-Annual Face-to-Face Meeting:
    - Where ?
    - When: Fall 2019
  - 11th Bi-Annual Face-to-Face Meeting:
    - Where ?
    - When: Spring 2020

Possibilities for Next Bi-Annual F45 Meetings
Spring 2019, Autumn 2020

Suggestions for this meeting were:

- **UMass-Lowell, MA, USA**
  - **April 29th – May 3rd wk**
- Fetch – San Jose, CA, USA
- Robotnik – Valencia, Spain (sent Roberto Guzman a LinkedIn message – said “we could be interested”)
- Balyo – near Paris, France (sent Fabien Bardinet a LinkedIn message – no reply)
- NIST, Gaithersburg, MD, USA
- Omron –San Francisco, CA, USA
- Omron – Netherlands

ASTM-Hosted Committee Weeks:

- Oct 21-25, 2019 - Houston, TX
- Mar 30-Apr 3, 2020 - Boston, MA
- May 11-15, 2020 - Boston, MA

Suggestions for this meeting were:

- MTC (Catapult centers) Dyson - UK
- MIR, also robot cluster - Denmark
- Disney, Universal Studios – Orlando, FL
- Mitsubishi, Diafuku, Sansei – Japan
- Rocla – Finland
- Technalia - Spain