OCCUPATIONAL SAFETY AND HEALTH STANDARDS BOARD (OSHSB)

AUTONOMOUS AGRICULTURAL TRACTORS ADVISORY COMMITTEE MEETING

May 8-9, 2025

Overview of Safety Standards and Practices for Autonomous Agricultural Machinery

Presented by:

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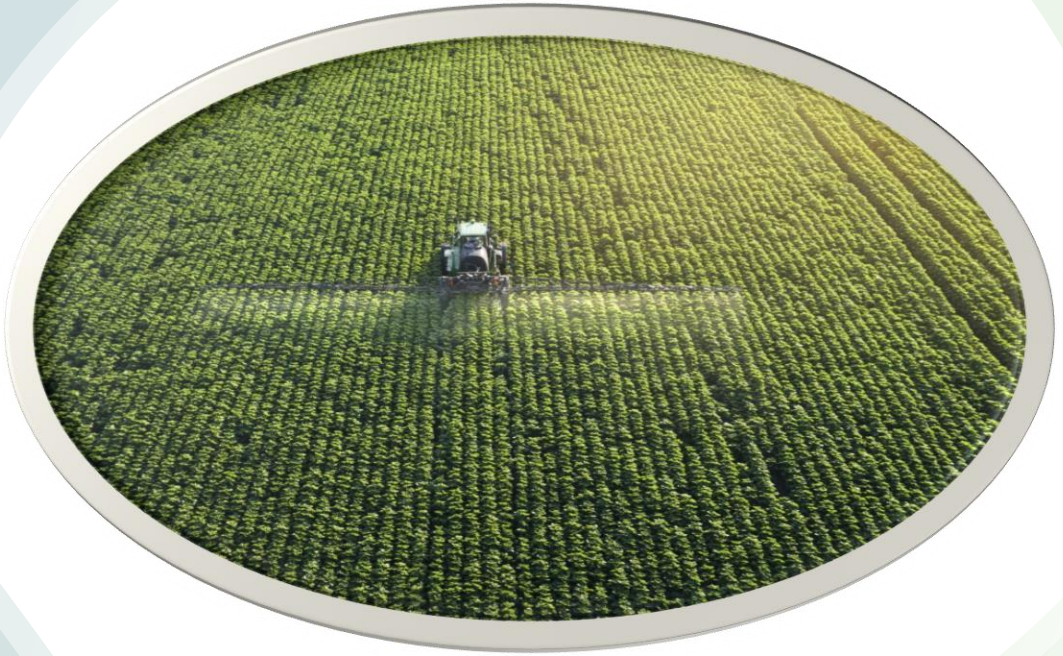
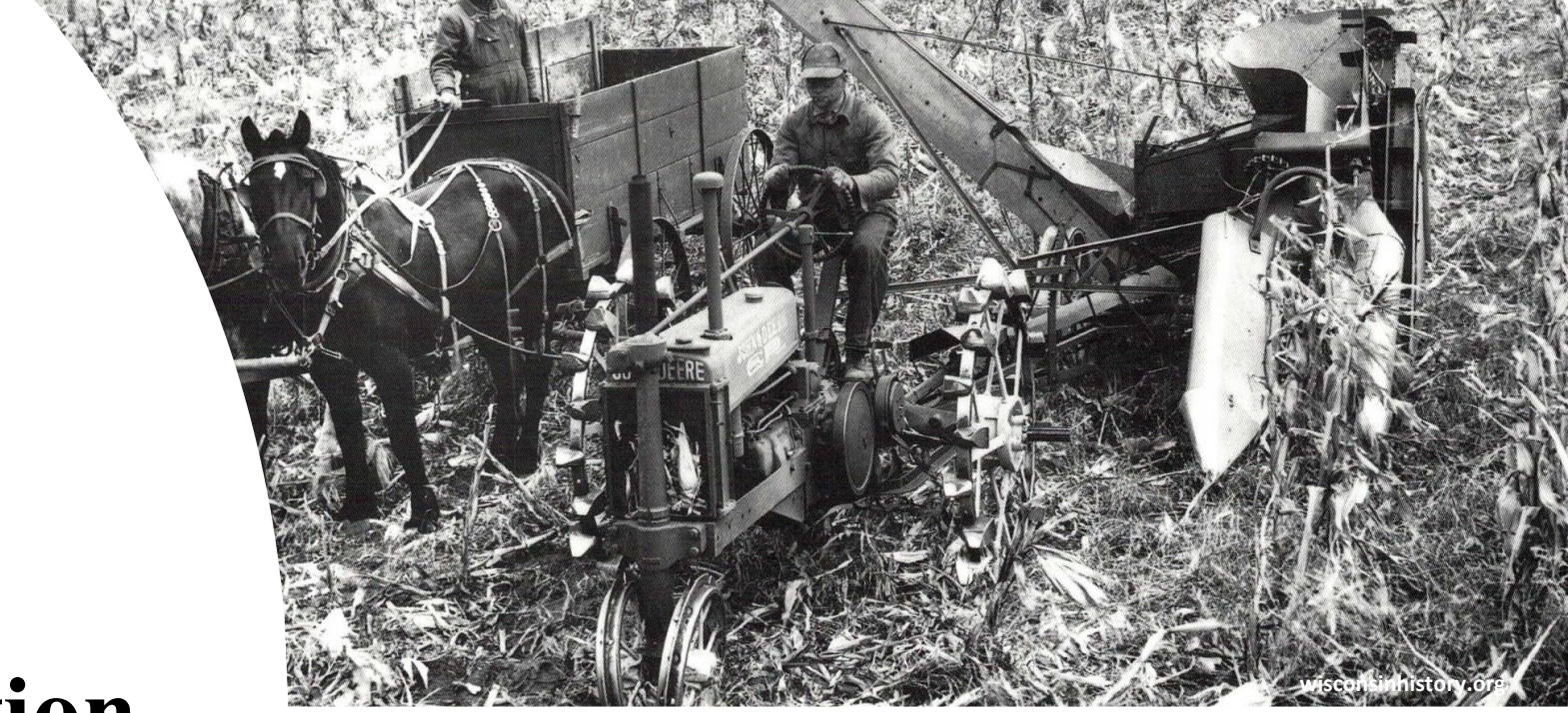
Outline

- History & Introduction
- California tractor safety regulations
- Petition No. 596
- ISO 18497 (4 parts)
- Code of Practice Australia



History & Introduction



Transition from Animal to Machine Power

- Late 1800s
- Number of horses on farms > tractors until 1954

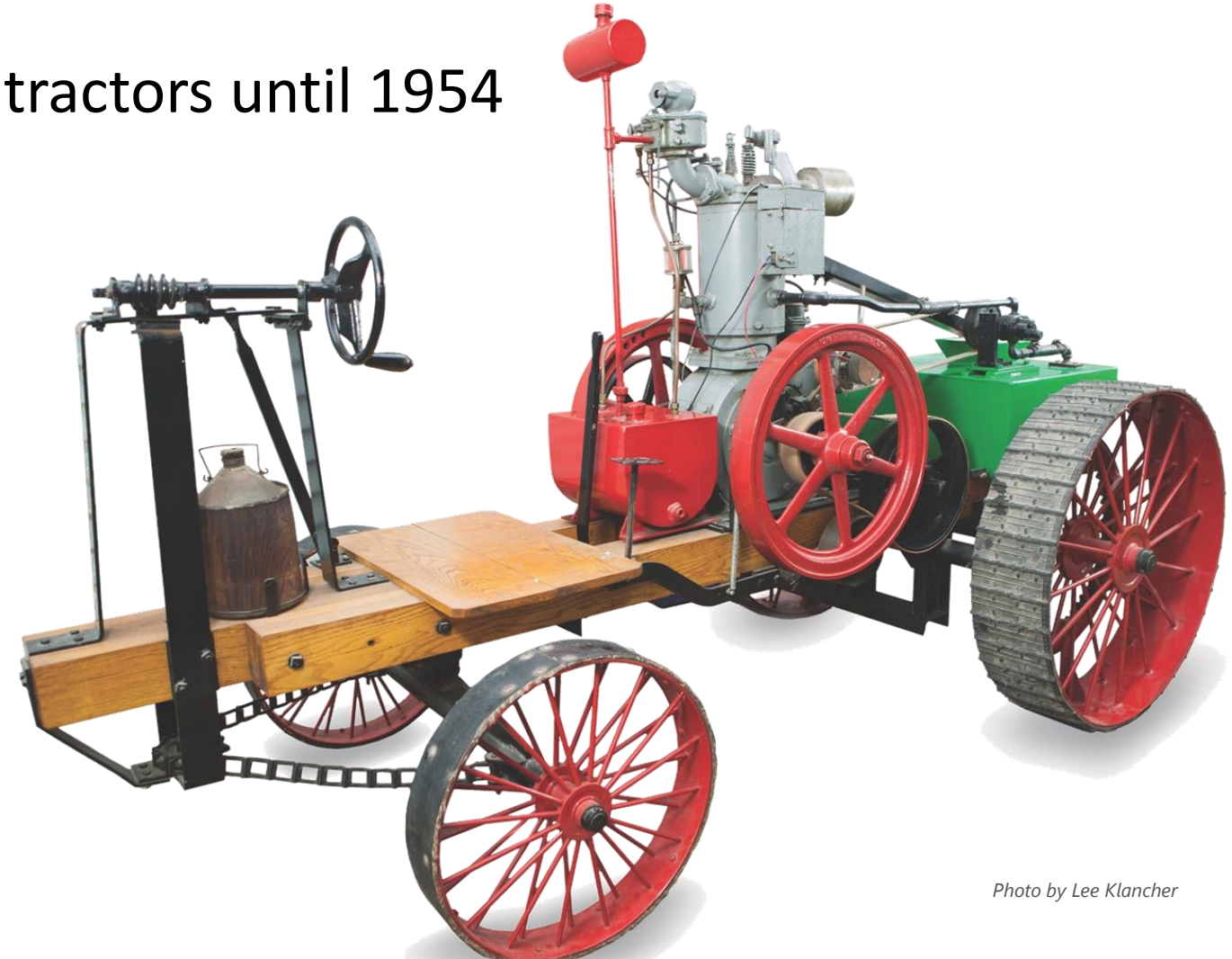
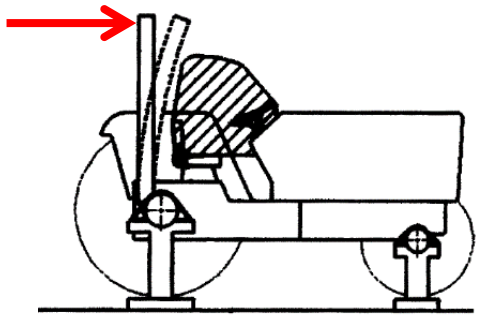


Photo by Lee Klancher

Nebraska tractor test station

Transition took Decades

- Industry standard for PTO, 1927 (ASAE)
- Safety – not until early 1960s
- First OSHA standards (ROPS) mid-1970s



California tractor safety regulations (Discussed yesterday)

§ 3441, Title 8 section (b), 1970's

All self-propelled equipment

- An operator stationed at the vehicular controls

Furrow guided self-propelled

- The operator sees the course and nearby employees.
- Controls reachable, not >10ft away.
- No climbing over obstacles to control.
- Speed less than 2 mph

Monarch petition

Effort to update regulations in Title 8, Section 3441(b)

Proposed Regulation Update

Exception for Self-Propelled Equipment
No onboard operator is required if specific conditions are met.

Proposed Regulation Upd

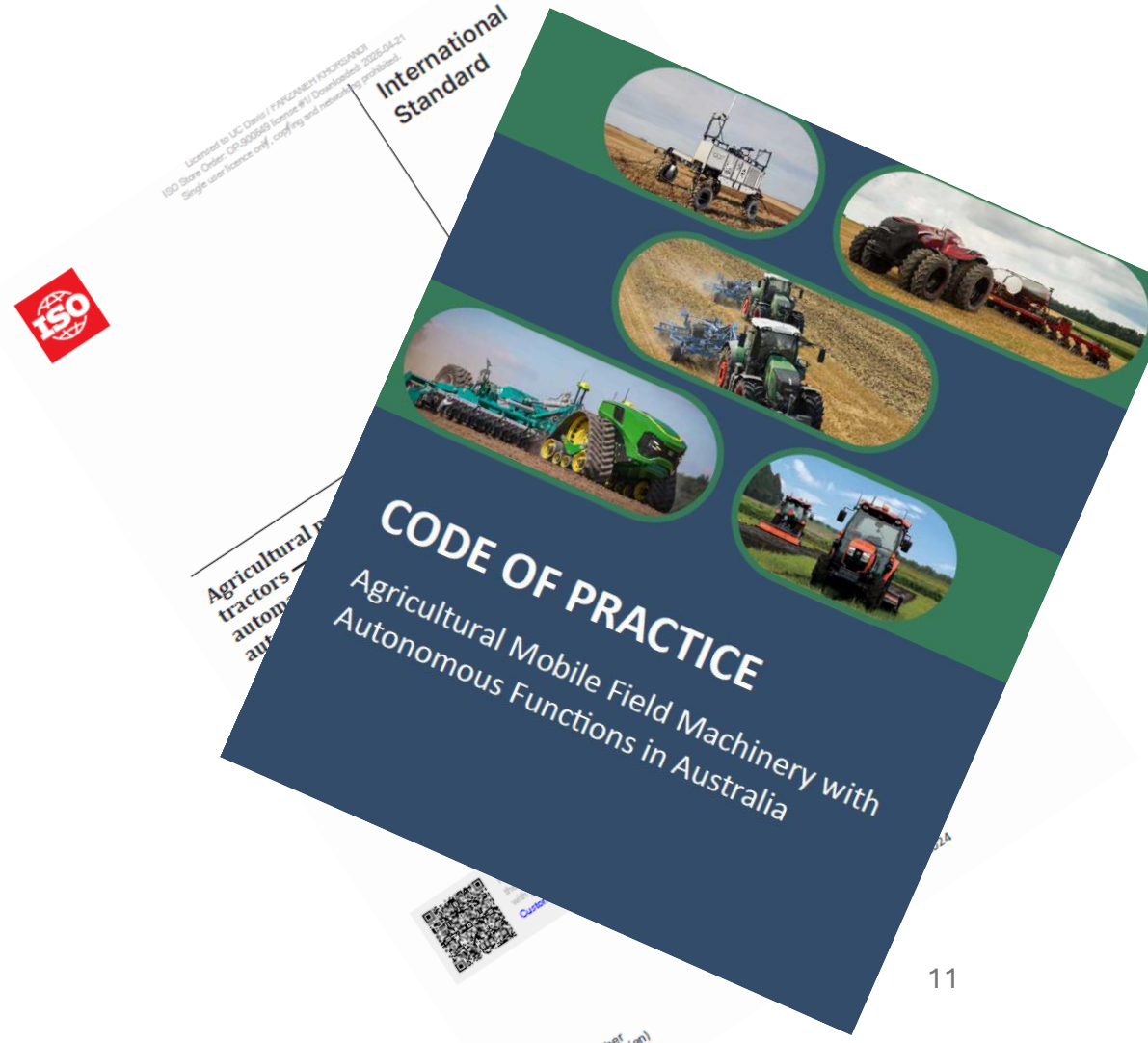
The petition (No. 596) was rejected by OSHSB.

Conditions:

1. Posted signs
2. Perc
3.
4.
5.
6. M
7. IS farmworker pro ety.

International Guidelines on Autonomous Agricultural Machinery Safety

- Safety ISO 18497
- CODE OF PRACTICE Agricultural Mobile Field Machinery with Autonomous Functions in Australia
- BS 8646:2023, titled "Use of Autonomous Mobile Machinery in Agriculture and Horticulture – Code of Practice“
- European Union – Regulation (EU) 2023/1230
- Functional safety ISO 25119



ISO 18497: Agricultural machinery and tractors — Safety of partially automated, semi-autonomous and autonomous machinery

First edition 2024-07

- Part 1: **Machine design principles and Vocabulary**
- Part 2: **Design principles for obstacle protection systems**
- Part 3: **Autonomous operating zones**
- Part 4: **Verification methods and validation principles**

SAE INTERNATIONAL

SAE AUTOMATION LEVELS

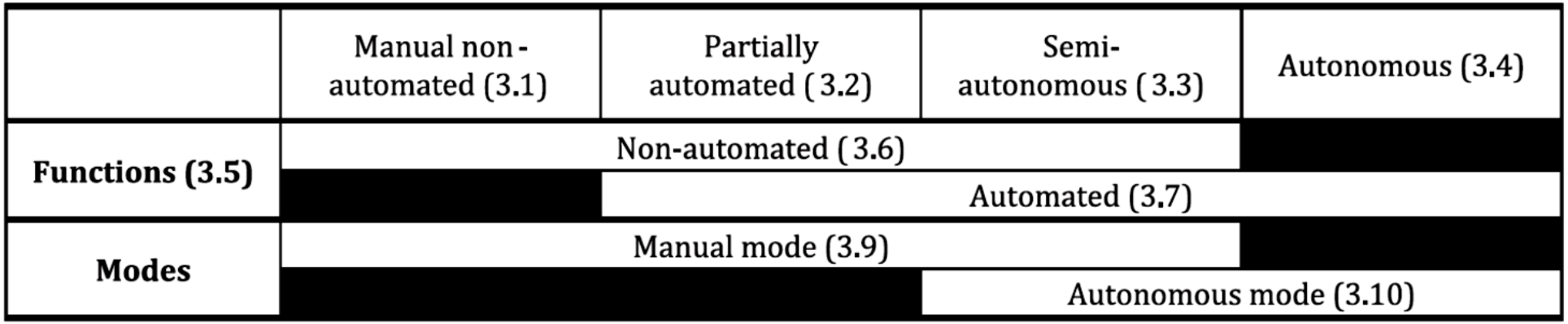
Full Automation

0	1	2	3	4	5
No Automation	Driver Assistance	Partial Automation	Conditional Automation	High Automation	Full Automation
Zero autonomy; the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	all times.	Driver is a necessity, times with notice.		The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

SAE J3016

ISO 18497 Part 1: Machine design principles and Vocabulary

- **Definition**



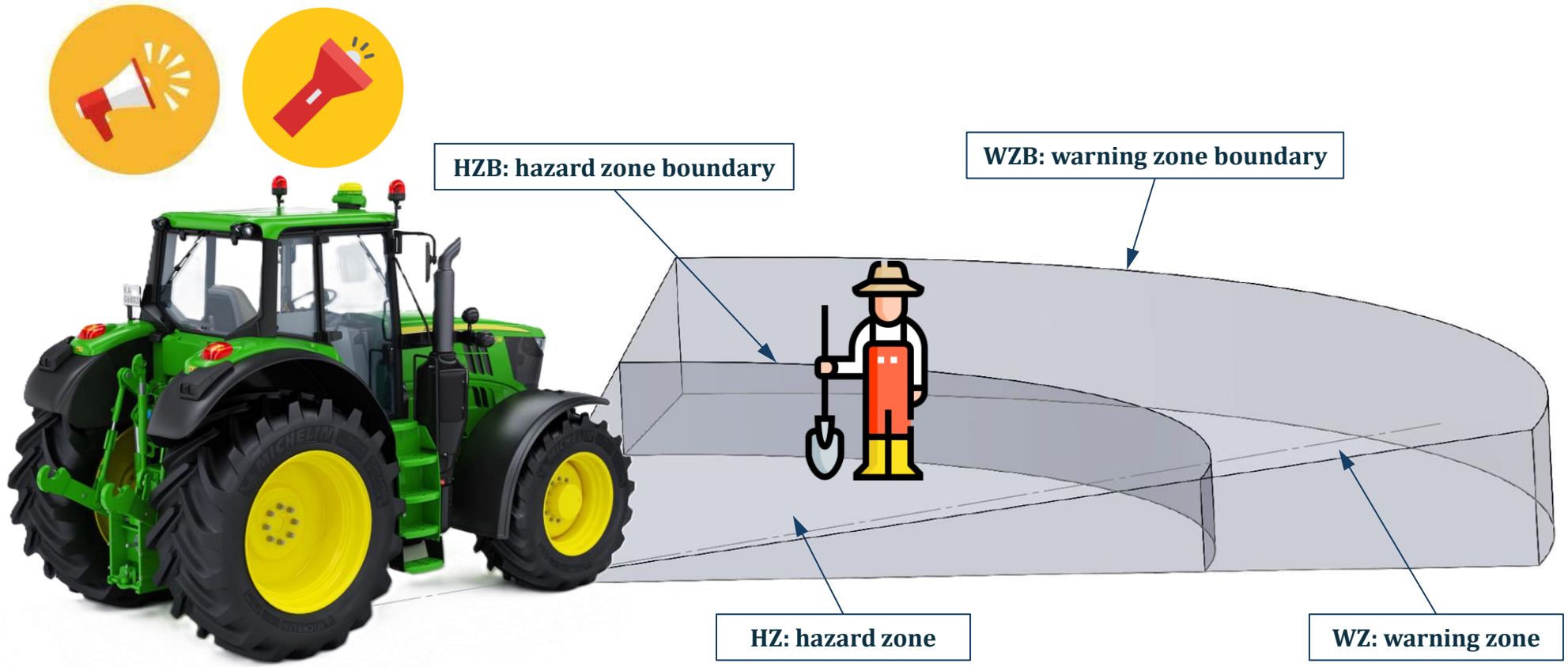
Manual non-automated, Partially automated, Semi-autonomous, Autonomous

Feature	Partially Automated	Semi-Autonomous
Operator needed full time	✅ Yes	❌ Not always
Automation does full task	❌ No	✅ Yes (some tasks)
Manual mode only	✅ Yes	❌ Uses both manual & autonomous
Example	Height control by sensors set point controlled by the operator.	Cultivator completes full field cycle autonomously

Audible/visual alarm signal that is intended to be detected by the human senses for hearing /sight

Obstacle protective system in autonomous mode of operation

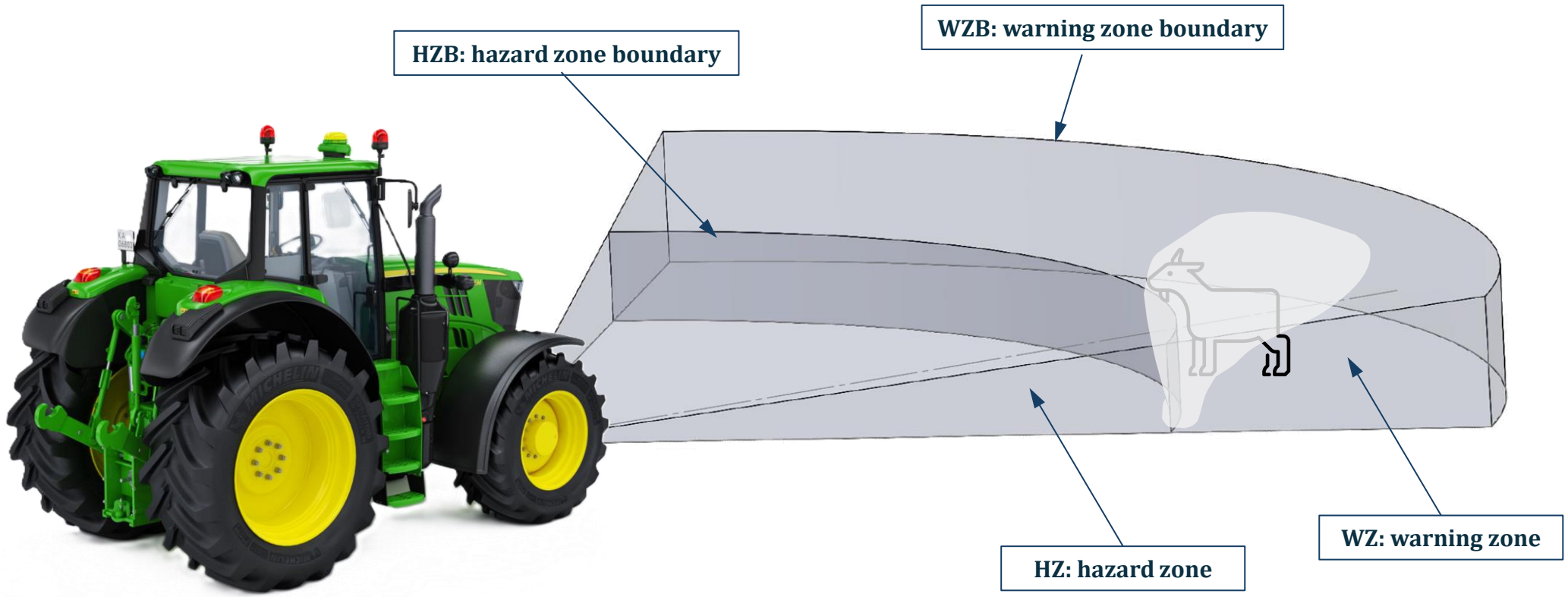
- **Visual Alarm**: flashing rate shall be higher than 125 flashes per minute (white, blue-green or amber colors)
- **Audible Alarm**: Different in interval, duration, and repeated cycle



https://www.cgtrader.com

ISO 18497 Part 2: Design principles for obstacle protection systems

- Obstacle detection — Perception and supervisory systems
  - Design recommendations for warning and hazard zones
  - Sensing technology (advantages & disadvantages)
  - Obstacle detection performance



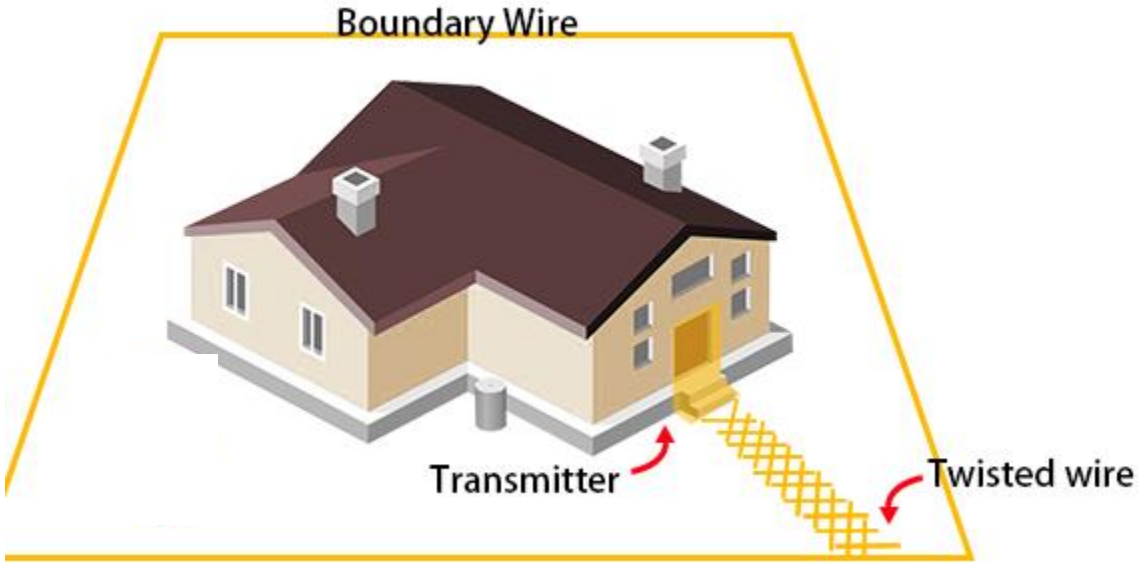
Part 3: Autonomous operating zones

Boundary detection

- Weather, lighting, terrain, sensor errors, or interference
- Virtual fence, peripheral protection systems, fixed path systems, buried wire

Geo-Fence

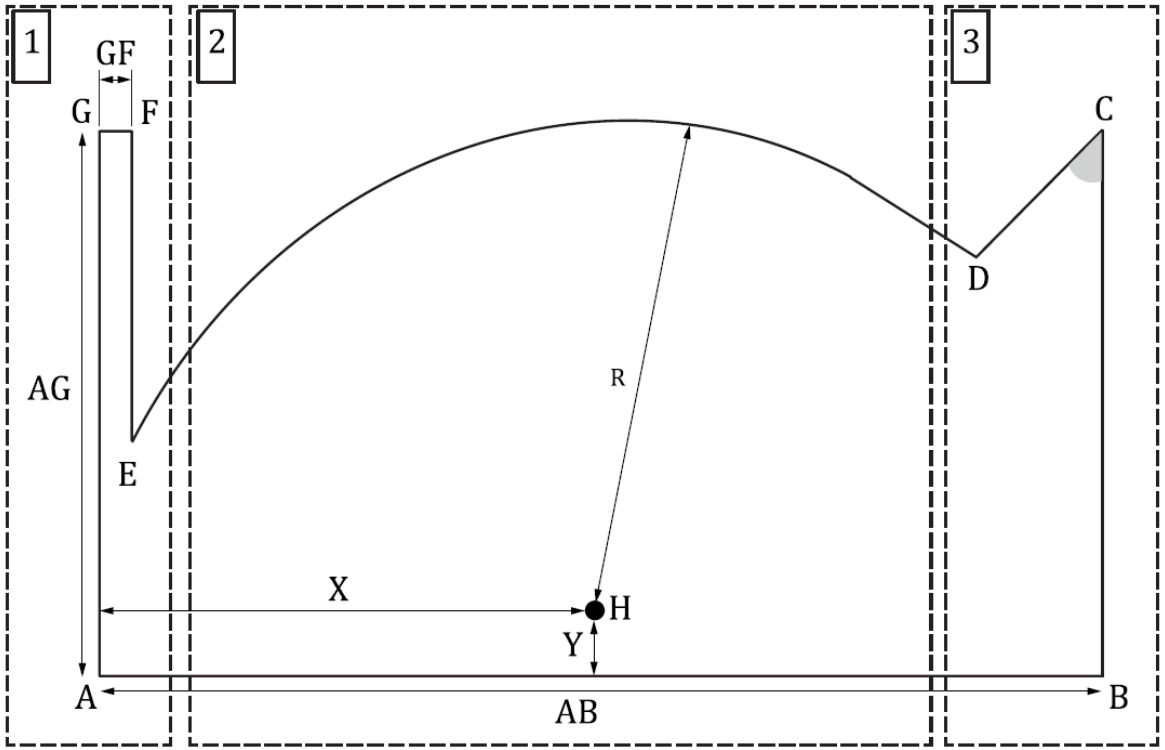
www.rkconnect.com



TRESSON

Part 4: Test procedure for autonomous operating zone

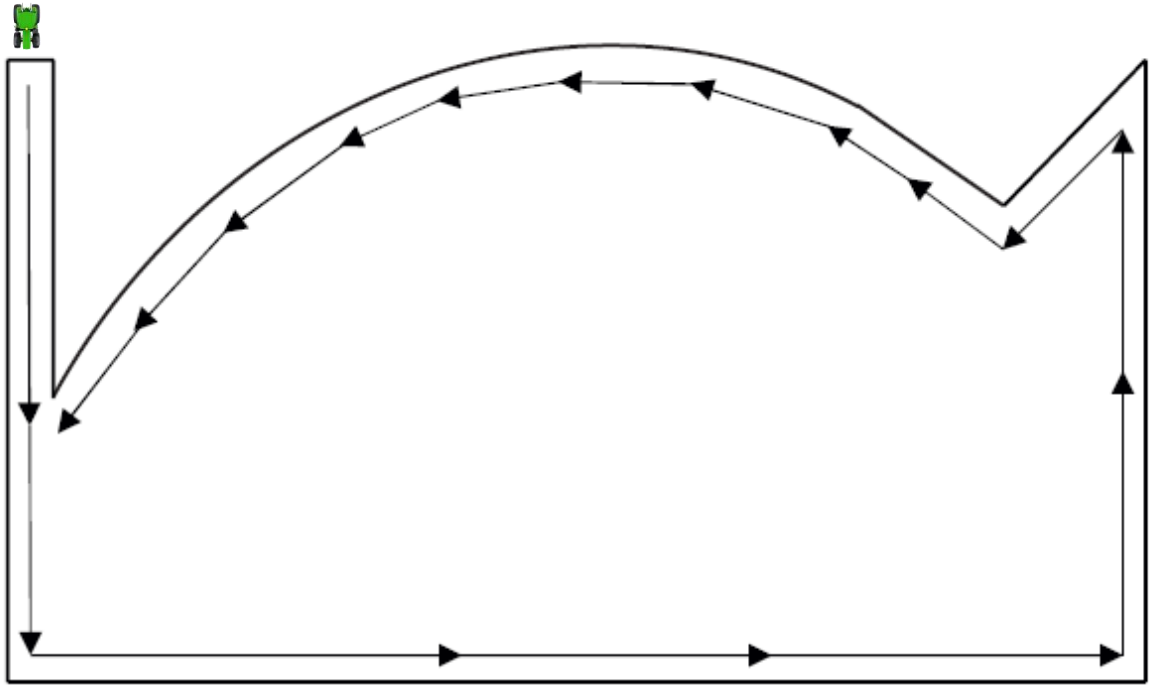
Terrain condition
Weather condition
Vehicle condition



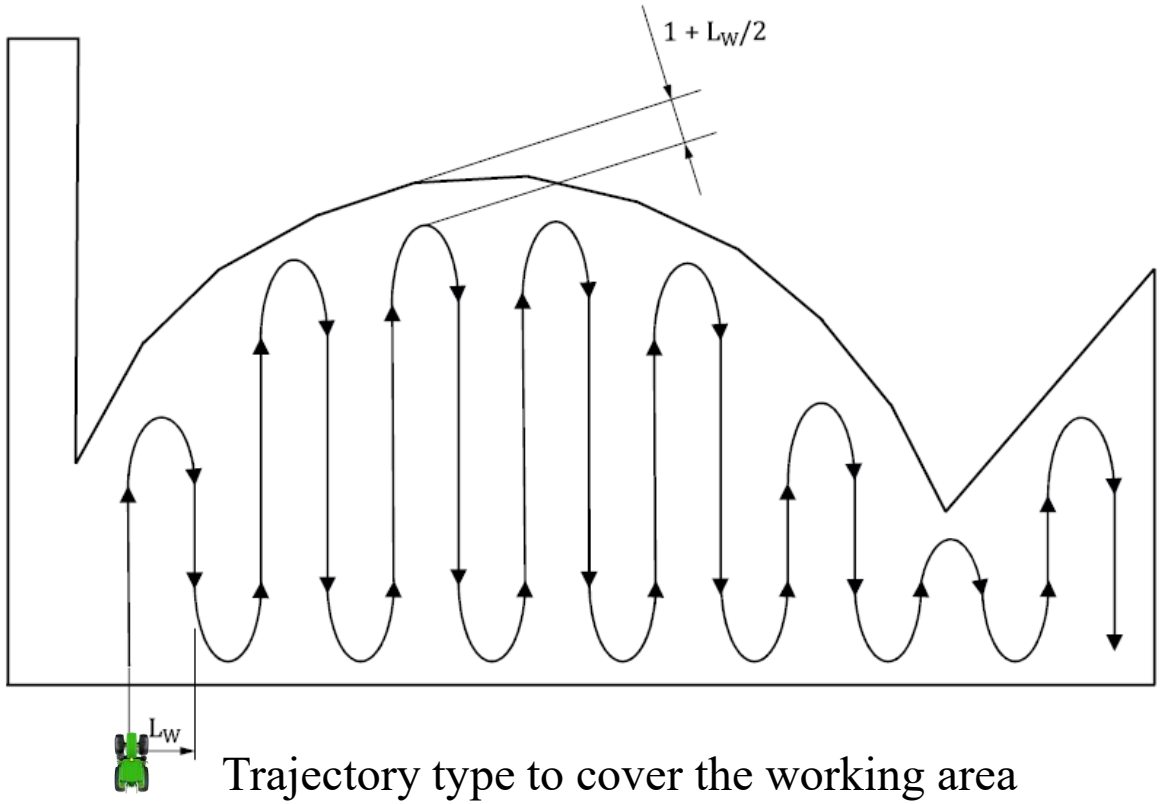
Parcel Dimension	Calculation
AG	α × (Lw + Long) / 2
BC	AG
AB	β × (Lw + Long) / 2
GF	1.5 × Lw
Y	(1/10) × AG
R, X	AB / 2
H	AB / 2

ISO 18497

Part 4: Test procedure for autonomous operating zone (Global validation test)

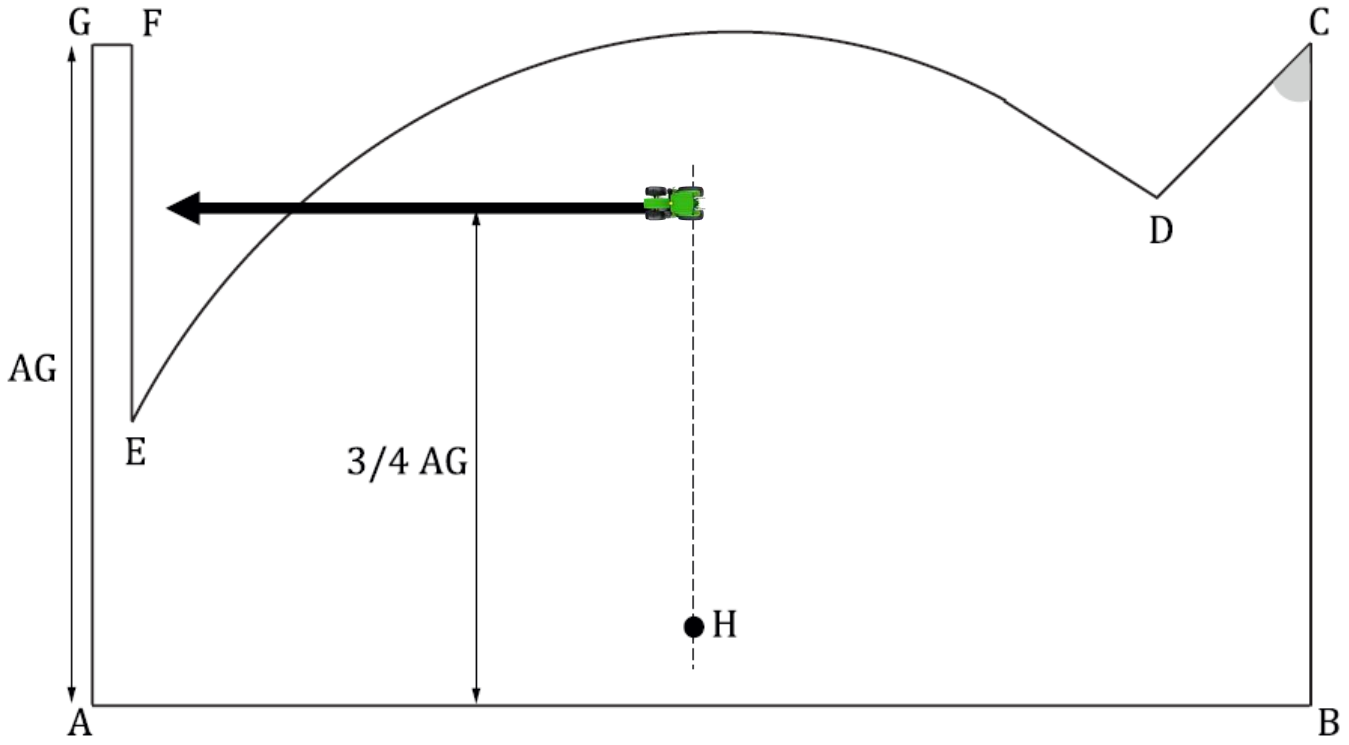


Trajectory type to simulate field outline work



Trajectory type to cover the working area

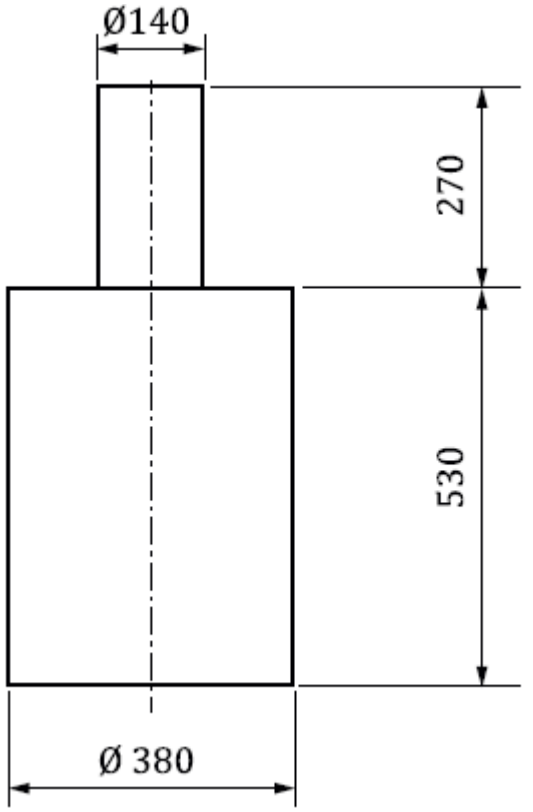
Part 4: Test procedure for autonomous operating zone (Edge crossing test)



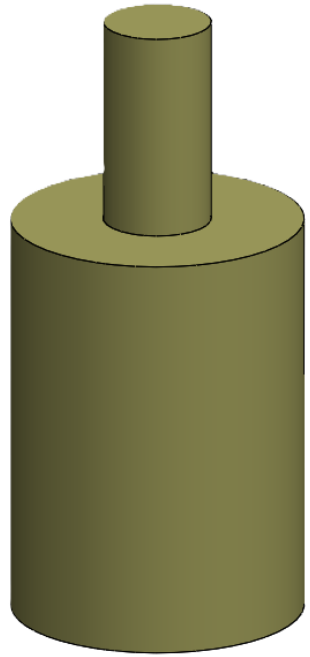
Part 4: Verification methods and validation principles

Obstacle protective system

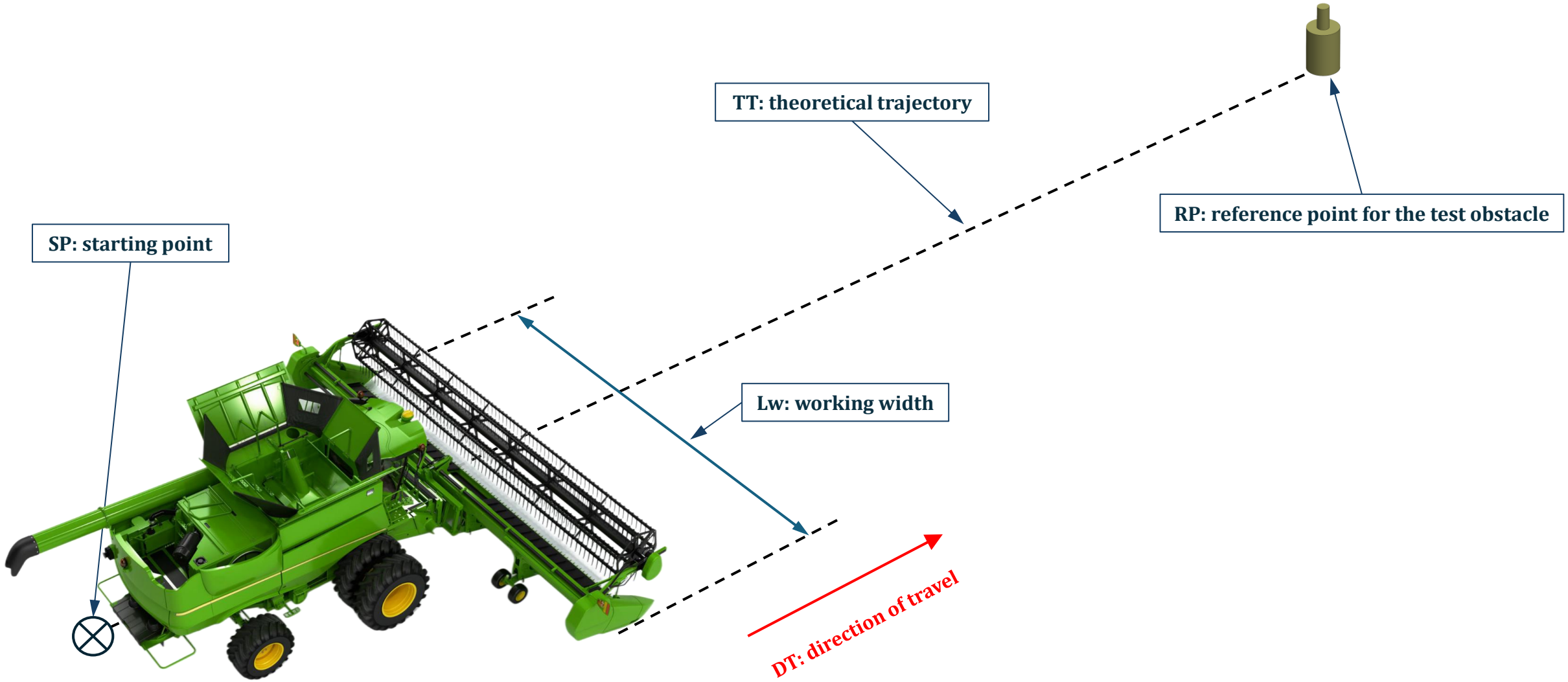
- Represents seated human, child, or animal
- Filled with water to simulate body composition
- Optional heating to simulate body temperature
- Made of plastic (e.g., polyethylene), matte surface
- Olive green color, matte finish

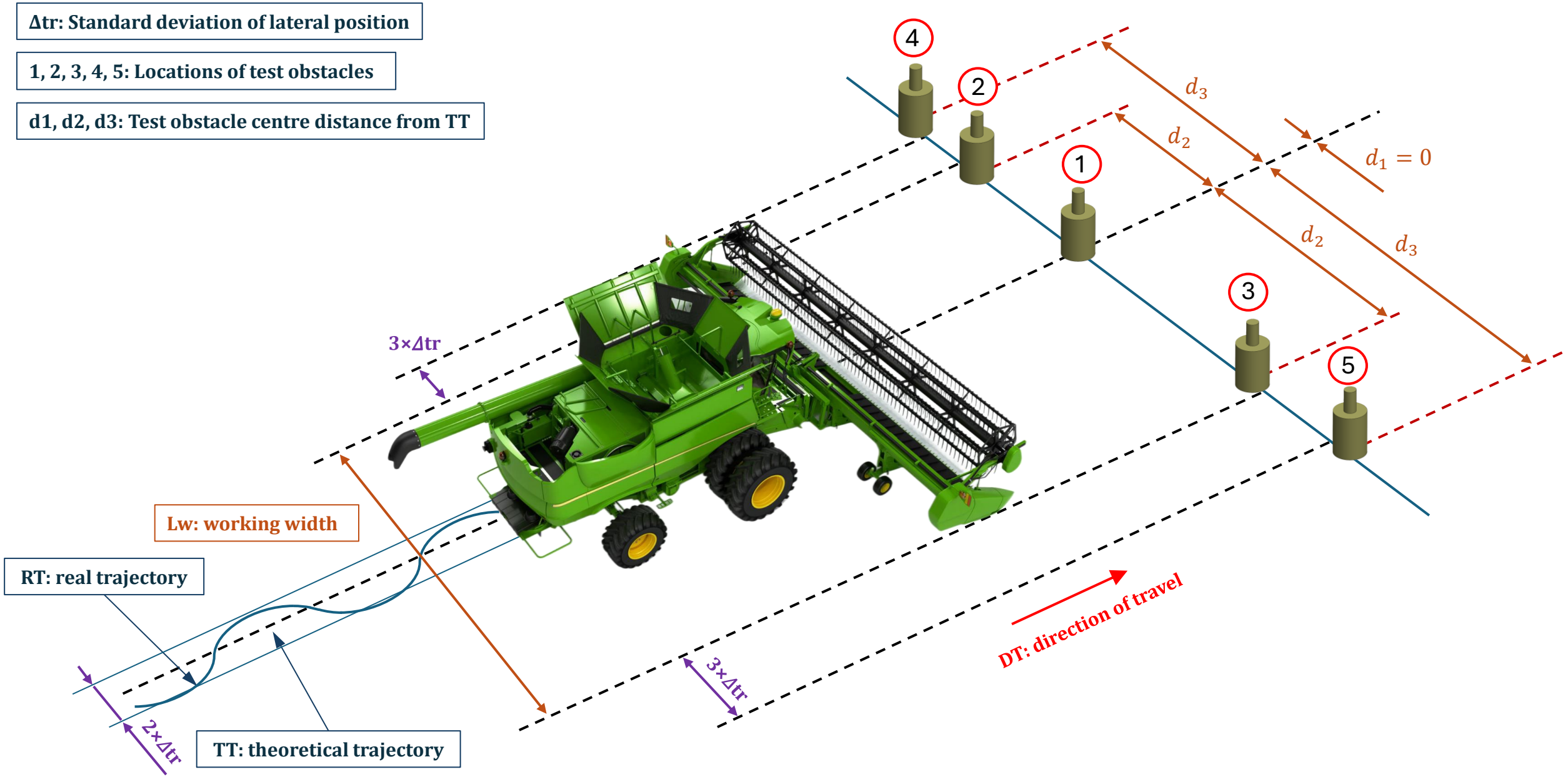


Dimensions in mm



Test parameters

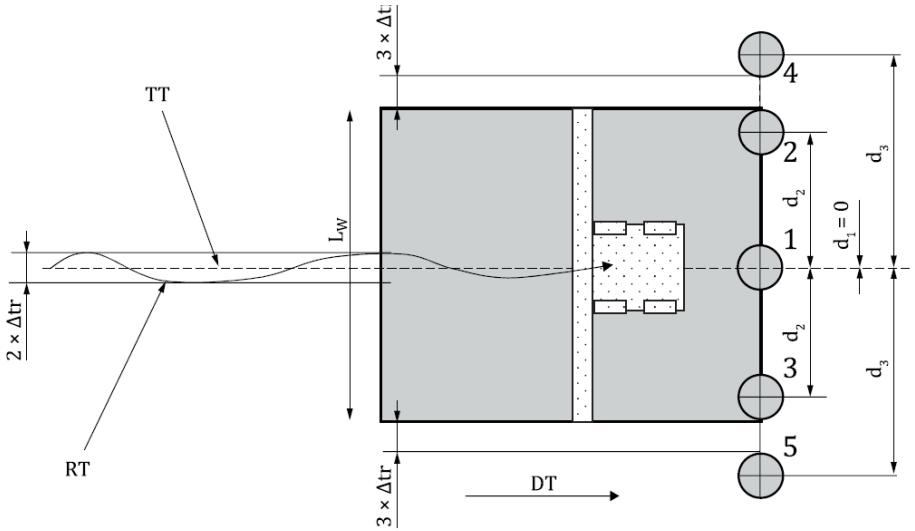




Test Obstacle Location and Distance from Theoretical Trajectory

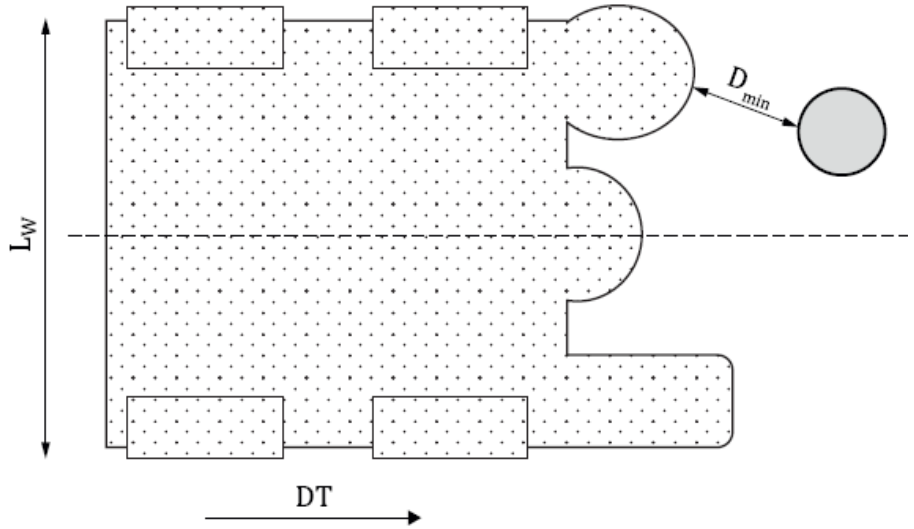
Location of Test Obstacle	Distance from Theoretical Trajectory
1	$d_1 = 0$
2 and 3	$d_2 = Lw / 2 - R$
4 and 5	$d_3 = Lw / 2 + 3\Delta tr + R$

Where:
Δtr: Standard deviation of lateral machine position relative to trajectory
R: Test obstacle maximum radius
Lw: Machine track width



Source: ISO 18497

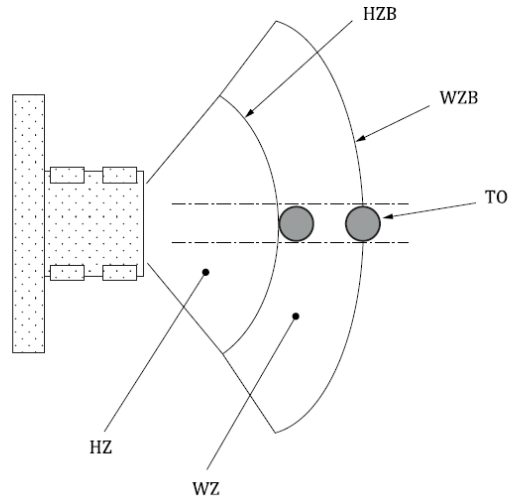
Measurement of minimum distance of machine and obstacle

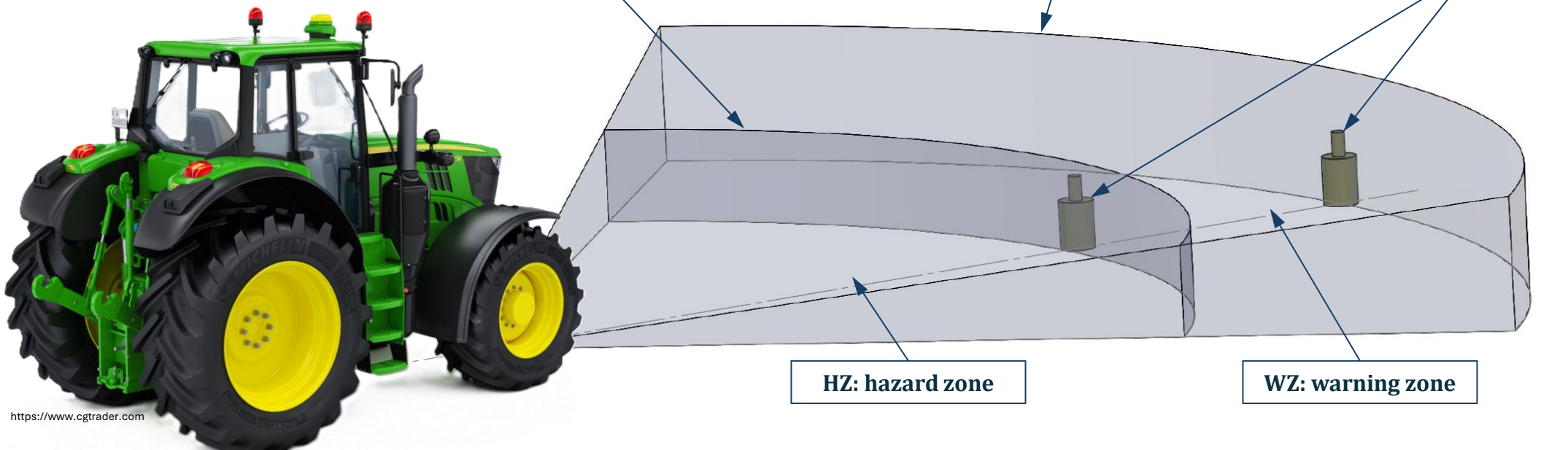


Lw	working width
D_{min}	minimum distance to test obstacle from machine outline
DT	direction of travel

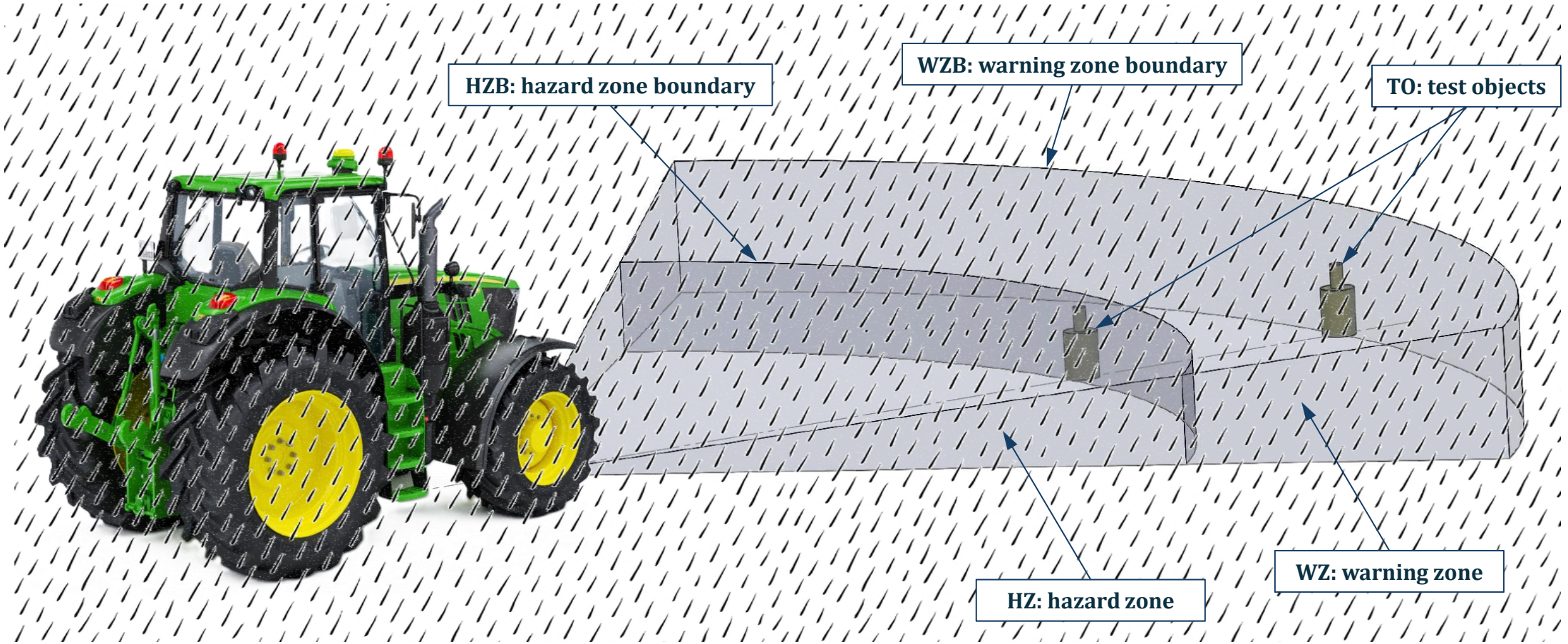
ISO 18497

Obstacle protective system under rain and fog environmental conditions

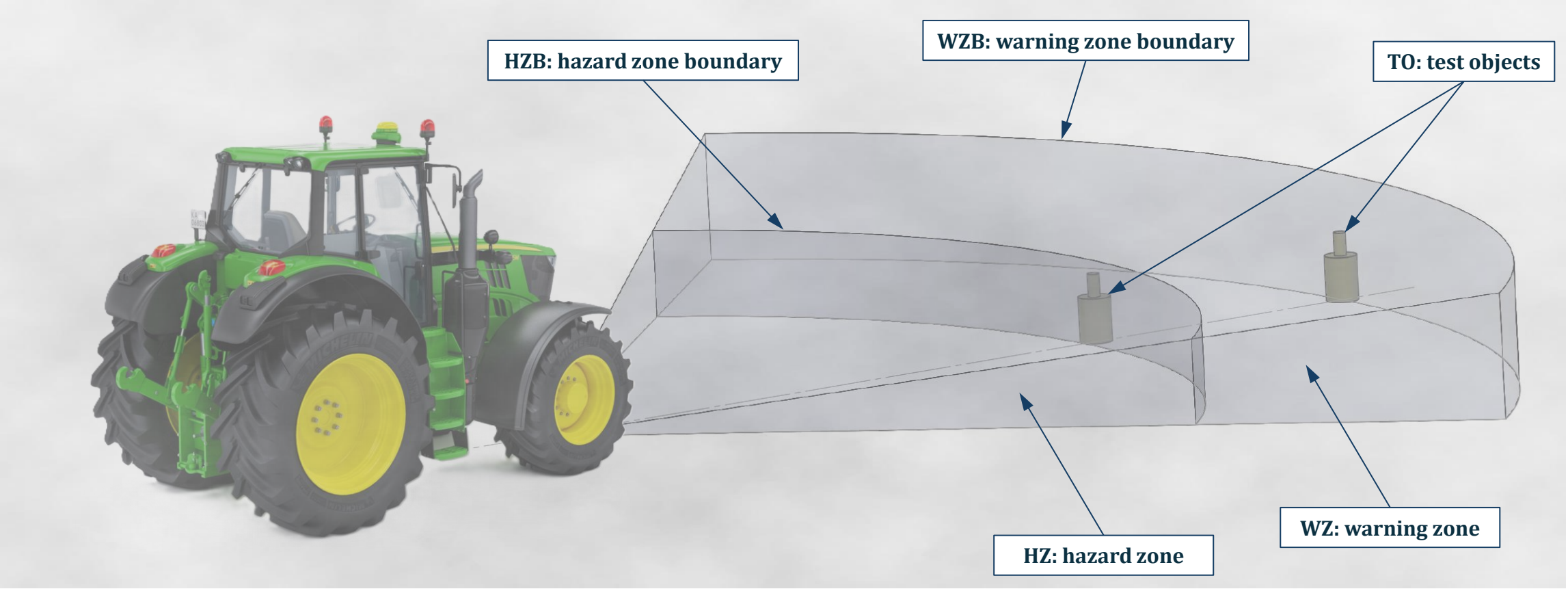




Obstacle protective system under rain environmental conditions

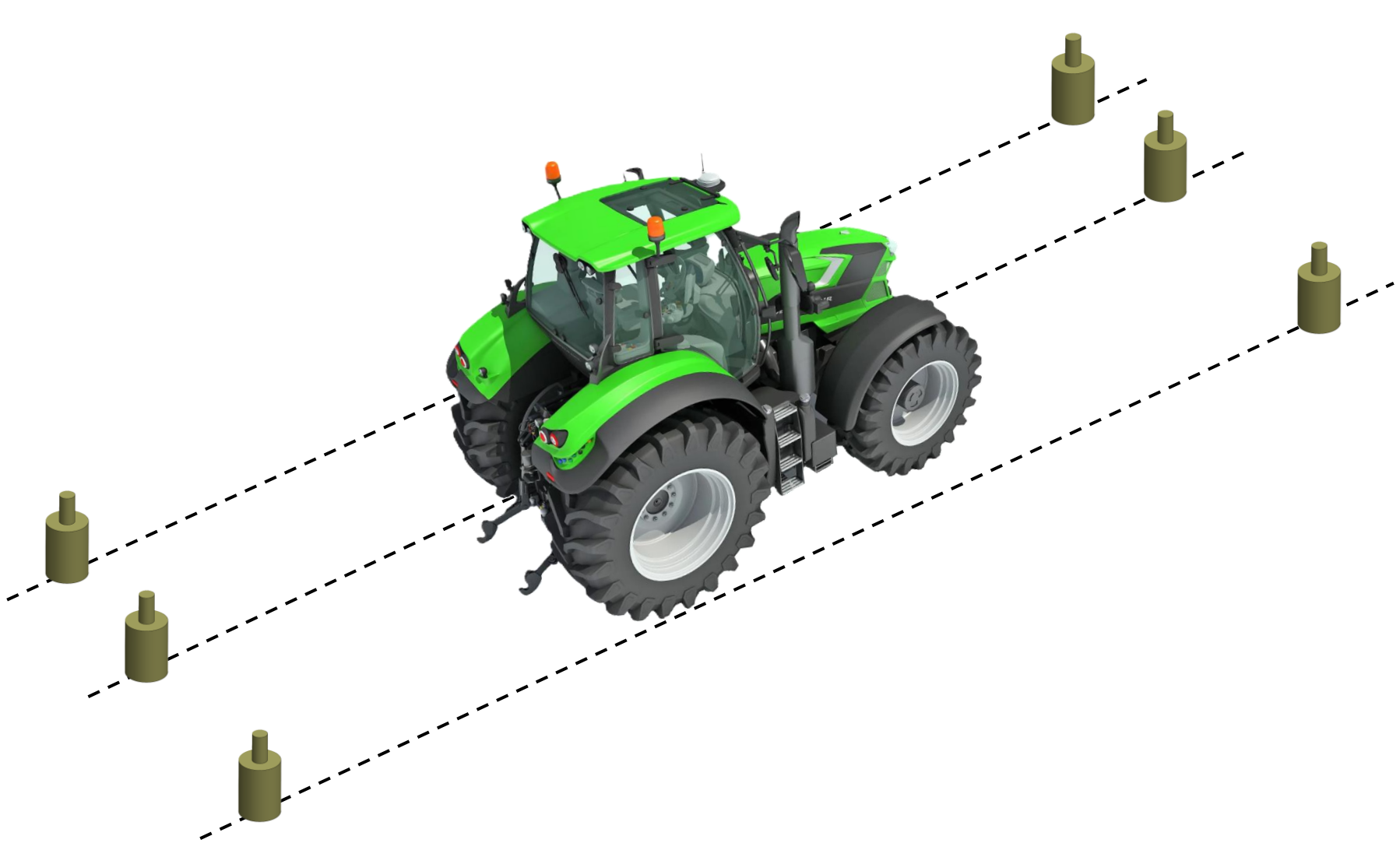


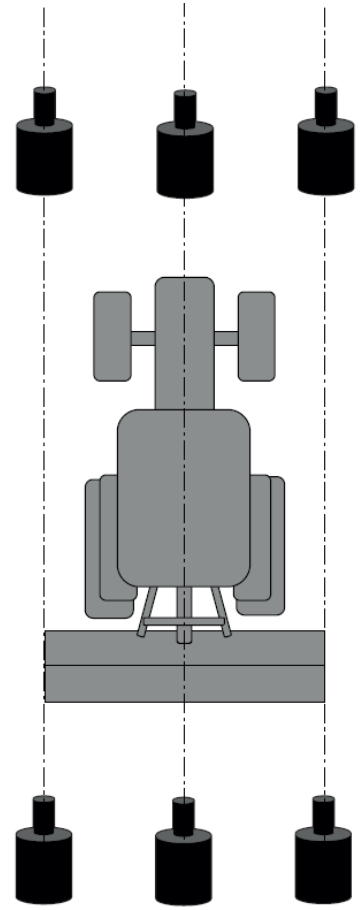
Obstacle protective system under fog environmental conditions



Test procedure for semi-autonomous and autonomous tractors

Person/obstacle detection function test





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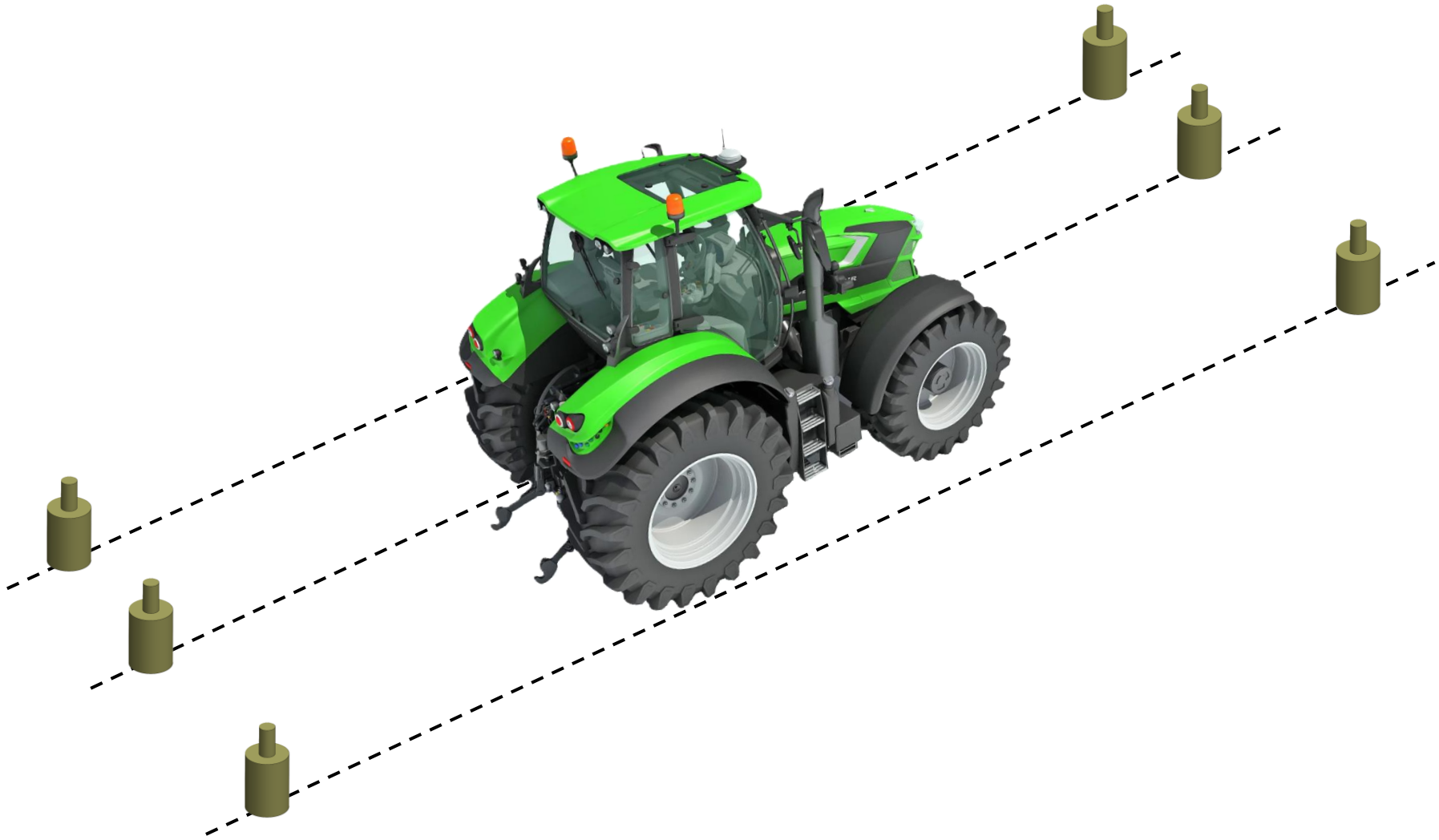
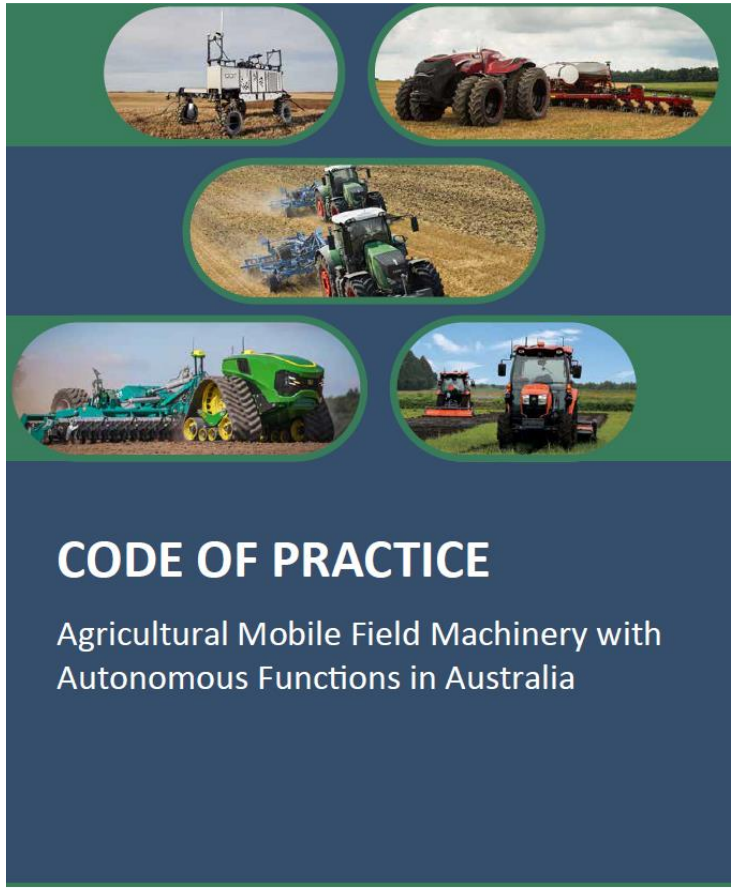


CODE OF PRACTICE Agricultural Mobile Field Machinery with Autonomous Functions in Australia

- Who should use this code of practice
- How to use this code of practice
- **Recommended using a list of standards**
  - Design
    - Safety ISO 18497
    - Functional safety ISO 25119
    - Agricultural machinery – Safety



Pesticide application

- Follow permits and laws.
- Operator holds legal responsibility.
- Apply only in approved conditions.
- Monitor in real time and keep records

Operational Management

- Vehicle Transport Between Fields
- Maintenance and Repair Requirements
- Emergency Management
  - Isolate all, or part of, the autonomous operating zone
  - Shut down the mobile equipment.

Questions?

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Acknowledgment:

- Payam Farhadi
- Western Center for Agricultural Health and Safety/NIOSH (grant 194 number #U54OH007550).