



# Safety Overview

## The Advantages of a Layered Safety Approach

Phantom's layered safety approach enables control of the vehicle to **remain in a human's hands**, while simultaneously relying on **automated complementary measures** such as audio and visual alerts to augment operator decision-making. Ultimately, our comprehensive **functional safety system** is designed as the final layer that safeguards against the unexpected — similar to Automatic Emergency Braking systems in passenger vehicles.



## Why a Layered Safety Methodology?





## Human-In-the-Loop

Human operators making real-time decisions in dynamic environments

## Predictive & proactive insights:

- Humans are best equipped to make judgment decisions in fast-paced material handling environments
- React in real time to unexpected events or circumstances, such as a person walking around a blind corner
- Quickly differentiate between animate and inanimate objects to minimize downtime, i.e. tape on the floor vs a human or a pallet

#### 360° Field of Vision:

- Camera system provides full & high-res view around the forklift
- Operator view is unobstructed by the frame of the chassis
- Does not require operators to turn in their seat to look over shoulder or drive in reverse, reducing risk of chronic injury

#### Additional Benefits:

- Situational awareness: operators can easily refer to forklift telemetry, fleet management information, and real-time data insights
- OSHA compliant: rigorous standardized training and certification
- Mitigating risk: removing operators from dangerous environment reduces risk of injury

## **Complementary Safety Measures**

Visual & audible indicators that prompt remote driver and on-site staff to recognize real-time changes and augment decision-making

## Remote Operator Console safety indicators & alerts:

- Remotely activated e-stop, speed gauges, tiered safety fields, object detection/avoidance & collision protection, active horn, environment
  recognition, protective stopping, speed limit constraints dynamically responsive to environment, and network latency conditions
- Operation Profiles (e.g., trailer mode, recovery mode)

#### **On-Vehicle safety indicators & alerts:**

Vehicle mode information, connection status, safety stop, blue position indicator lights, start up lights, safety field alarm lights, and active horn

#### 2-Way Audio Communication:

- Enables open communication between the remote operator and on-site staff
- · Allows bi-directional communication with on-site staff around the vehicle
- Provides "situational awareness" feedback around the vehicle

(e.g., relevant sounds, perception of environmental elements, and contextual information)

## **Functional Safety System**

All safety functions are designed to meet the relevant performance level determined during the risk assessment process and are designed to meet ISO 13849-1

 Safety sensor solution that meets all relevant\* sections of ANSI B56.5 (the common reference standard for AGVs), along with other relevant safety standards and best practices

### Intelligent Obstacle Detection, Avoidance and Collision Protection:

- LIDAR sensors and safety encoders that intelligently slow or safely stop vehicle based on sensor inputs
- Dynamic warning and protective field profiles that change based on vehicle direction, speed, and angle (warning field slows the vehicle; protective field stops the vehicle)

#### Designed with redundant safeguards and diagnostics that solve for complexities such as:

- Latency threshold alerts, network connectivity issues, power errors, or mechanical failures
- Configured to safely stop or slow the vehicle to mitigate unforeseen risks, such as when latency exceeds a certain threshold
- Incorporates highly reliable & independently tested safety components (e.g., safety controllers), and safety architectures designed appropriately to mitigate failures