# ISO 26262 Part 3 - Item Definition Review Report

Item Definition

Item: Wiper\_and\_Washer\_System

ISO 26262 Item Definition: Wiper and Washer System

*Work Product: 5.5.1 – Item definition resulting from requirements in 5.4*

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1. Introduction

*Clause: 5.1, 5.2*

Item Definition: Wiper and Washer System

**Item:** Wiper and Washer System

**1. Introduction and Role in the Vehicle:**

The Wiper and Washer System is a critical safety and comfort feature integrated into the vehicle's exterior. Its primary function is to maintain clear visibility for the driver by removing obstructions from the windshield and, in some vehicles, other glass surfaces like rear windows or headlights.

The system comprises several key components:

• **Wiper Blades:** These flexible rubber or silicone blades physically sweep across the glass surface, dislodging and pushing away water, snow, dirt, and other debris.

• **Wiper Motor(s):** An electric motor provides the mechanical power to move the wiper arms and blades in their designated arc.

• **Wiper Arms:** These connect the wiper motor to the wiper blades, translating the motor's rotational motion into the sweeping action.

• **Washer Pump:** An electric pump draws washer fluid from a reservoir and propels it through the washer fluid lines.

• **Washer Nozzles:** These strategically positioned nozzles spray washer fluid onto the windshield, lubricating the surface and aiding in the removal of stubborn dirt and grime.

• **Washer Fluid Reservoir:** A container that stores the washer fluid.

• **Control Module/Switches:** User interfaces (typically on the steering column stalk) that allow the driver to activate, deactivate, and control the speed and operation of the wipers and washer system. In modern vehicles, this may also involve an Electronic Control Unit (ECU) for more sophisticated control logic.

The Wiper and Washer System plays a vital role in:

• **Ensuring Driver Visibility:** This is its paramount function. Clear visibility is essential for safe driving, allowing the driver to perceive hazards, road markings, other vehicles, and pedestrians.

• **Enhancing Driving Comfort:** By removing rain and debris, the system significantly improves the driving experience, especially in adverse weather conditions.

• **Maintaining Vehicle Aesthetics:** Keeping the glass clean contributes to the overall appearance of the vehicle.

**2. Why This Definition is Needed for Functional Safety (e.g., to Align Stakeholders Before HARA):**

Defining the "Wiper and Washer System" as the **Item** under development is a fundamental and crucial step in the **Hazard Analysis and Risk Assessment (HARA)** process, and it serves to **align stakeholders** before this critical analysis begins. Here's why:

• **Scope Definition and Boundary Setting:** The Item definition clearly delineates what is *included* within the scope of our safety analysis and what is *excluded*. This prevents ambiguity and ensures that all relevant components and functionalities are considered, while avoiding unnecessary analysis of unrelated systems. For example, it clarifies that we are analyzing the *operation* of the wipers and washers, not the structural integrity of the windshield itself.

• **Common Understanding and Language:** Before HARA, all stakeholders (e.g., design engineers, safety engineers, system architects, project managers, testing teams) need to have a shared understanding of what "Wiper and Washer System" refers to. This definition provides a common language and a single point of reference, preventing misinterpretations and ensuring everyone is working with the same set of assumptions.

• **Identification of Potential Hazards:** By clearly defining the Item, we can begin to brainstorm potential failure modes and their associated hazards. For instance, if the Item is defined as "Wiper and Washer System," stakeholders can immediately think about:

• Wipers failing to operate when needed (e.g., during heavy rain).

• Wipers operating continuously and uncontrollably.

• Washer fluid not being dispensed.

• Wiper blades detaching.

• Incorrect wiper speed for the conditions.

• **Facilitating Hazard Identification:** A well-defined Item allows for a more systematic and comprehensive identification of hazards. Without a clear definition, the HARA team might overlook critical failure scenarios or focus on aspects that are not part of the system being developed.

• **Enabling Risk Assessment:** Once hazards are identified, the Item definition helps in assessing the severity, exposure, and controllability of each hazard. For example, the severity of "wipers failing to operate during heavy rain" is directly linked to the loss of driver visibility, a critical safety concern.

• **Basis for Safety Requirements:** The Item definition forms the foundation for deriving safety goals and functional safety requirements. For instance, if the Item is defined to include the automatic activation of wipers based on rain sensors, then the HARA will identify hazards related to false activation or non-activation, leading to specific safety requirements for the rain sensor and its integration.

• **Stakeholder Alignment and Buy-in:** Presenting a clear Item definition before HARA ensures that all stakeholders agree on the system's boundaries and intended functionality. This agreement is crucial for gaining buy-in for the subsequent safety activities and for ensuring that the safety objectives are aligned with the overall project goals.

In essence, defining the Wiper and Washer System as the **Item** is the **first crucial step in establishing a robust functional safety process**. It provides the necessary clarity and common ground for all involved parties to effectively identify, analyze, and mitigate potential risks, ultimately leading to a safer vehicle for the end-user.

2. Requirements of the Item

*Clause: 5.4.1*

2.1 Legal Requirements, National and International Standards

*Clause: 5.4.1 a)*

The design and safety of a Wiper and Washer System, especially in the context of modern vehicles, are influenced by a range of laws, regulations, and standards. These can be broadly categorized as follows:

**I. Vehicle Safety Regulations (Mandatory)**

These are legally binding requirements that vehicles must meet to be sold and operated on public roads.

• **UNECE Regulations (United Nations Economic Commission for Europe):** These are widely adopted by many countries and form the basis for many national regulations.

• **UNECE R100 (Uniform provisions concerning the approval of vehicles with regard to the specific requirements for the construction of electrically propelled vehicles concerning battery systems):** While primarily focused on electric vehicle battery systems, it has implications for the overall electrical system safety of EVs, which includes components like the wiper and washer system. It addresses aspects like electrical safety, thermal management, and mechanical integrity.

• **UNECE R121 (Uniform provisions concerning the approval of vehicles with regard to the identification of controls, tell-tales and indicators):** This regulation ensures that controls for systems like wipers and washers are clearly identifiable and understandable to the driver.

• **UNECE R118 (Uniform provisions concerning the prevention of fire risks):** While not directly about wipers, it covers general fire safety in vehicles, which could indirectly influence material choices and wiring practices for the wiper system.

• **UNECE R13 (Braking):** While not directly related, the overall vehicle safety context means that any system that could potentially distract the driver or affect visibility needs to be considered within the broader safety framework.

• **National Regulations (Examples):**

• **FMVSS (Federal Motor Vehicle Safety Standards) in the USA:**

• **FMVSS 104 (Windshield Wiping and Washing Systems):** This is a crucial standard that specifies performance requirements for windshield wiping and washing systems, including wiping effectiveness, coverage, and washer fluid delivery.

• **FMVSS 108 (Lamps and Reflective Devices):** While primarily for lighting, it touches upon visibility and the importance of clear windshields, indirectly supporting the need for effective wipers.

• **FMVSS 118 (Side Impact Protection):** Again, not directly about wipers, but the overall safety context is important.

• **ECE Regulations (adopted by many European countries):** Many European countries directly adopt UNECE regulations.

• **Other National Regulations:** Countries like Japan (JIS standards), China (GB standards), and others have their own specific vehicle safety regulations that often align with or are based on UNECE standards.

**II. Functional Safety Standards (Industry Best Practices & Increasingly Mandated)**

These standards provide a framework for managing functional safety risks throughout the product lifecycle.

• **ISO 26262 (Road vehicles – Functional safety):** This is the **most critical standard** for the safety of automotive electrical and electronic systems. It defines a systematic approach to achieve functional safety, which is essential for systems that could lead to hazardous events if they fail.

• **Hazard Analysis and Risk Assessment (HARA):** Identifying potential hazards associated with wiper and washer system failures (e.g., failure to clear the windshield in rain, unexpected activation causing distraction).

• **Safety Goals:** Defining safety objectives to mitigate identified risks.

• **Automotive Safety Integrity Levels (ASILs):** Determining the ASIL for different functions of the wiper and washer system based on the severity, exposure, and controllability of potential hazards. This dictates the rigor of the development process.

• **Safety Requirements Specification:** Defining detailed safety requirements for hardware and software.

• **Design and Development Processes:** Implementing safety-oriented design principles, verification, and validation activities.

• **Production and Operation:** Ensuring safety is maintained throughout the product lifecycle.

• **IEC 61508 (Functional safety of electrical/electronic/programmable electronic safety-related systems):** This is the **generic international standard** for functional safety. ISO 26262 is derived from IEC 61508 and is specifically tailored for the automotive industry. While ISO 26262 is the primary standard for automotive applications, understanding IEC 61508 can provide a broader context for functional safety principles.

**III. Electromagnetic Compatibility (EMC) Standards (Mandatory)**

These standards ensure that electronic systems do not interfere with each other and are not susceptible to external electromagnetic interference.

• **UNECE R10 (Uniform provisions concerning the approval of vehicles with regard to electromagnetic compatibility):** This is a fundamental regulation for vehicle EMC. It covers both emissions (preventing the vehicle's systems from interfering with other devices) and immunity (ensuring the vehicle's systems are not affected by external electromagnetic fields).

• **ISO 11452 (Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy):** This series of standards specifies test methods for evaluating the immunity of automotive electronic components to radiated electromagnetic energy.

• **ISO 7637 (Road vehicles – Electrical disturbances from conduction and coupling):** This series of standards defines test methods for evaluating the immunity of automotive electrical systems to transient voltage pulses and other conducted disturbances.

• **National EMC Regulations:** Many countries have their own specific EMC regulations, often harmonized with UNECE R10 or other international standards.

**IV. Electrical System and Component Standards (Industry Best Practices & Often Referenced)**

These standards provide guidance on the design, testing, and reliability of electrical components and systems.

• **ISO 21748 (Guidance to the application of statistical techniques to ISO 26262):** While not a direct design standard, it provides guidance on using statistical methods for safety analysis and verification, which can be applied to wiper and washer system components.

• **ISO 16750 (Road vehicles – Environmental conditions and testing for electrical and electronic equipment):** This standard specifies environmental conditions (temperature, humidity, vibration, etc.) and corresponding test procedures for automotive electrical and electronic equipment, including components of the wiper and washer system.

• **SAE Standards (Society of Automotive Engineers) in the USA:**

• **SAE J1127 (Low Voltage Wiring and Cable):** Relevant for the wiring harness of the wiper and washer system.

• **SAE J1939 (Recommended Practice for Serial Control and Communications Multiplexing Network):** If the wiper and washer system is controlled via a CAN bus or other multiplexed network, this standard (or similar) would be relevant for communication protocols.

• **SAE J2590 (Automotive Diagnostic Data Standards):** Relevant for diagnostic capabilities of the system.

• **IEC Standards (International Electrotechnical Commission):**

• **IEC 60068 (Environmental testing):** A broad series of standards for environmental testing of electronic components.

• **IEC 60529 (Degrees of protection provided by enclosures - IP Code):** Relevant for the ingress protection of the wiper motor, washer pump, and other electrical components against dust and water.

**V. Material and Component Specific Standards**

• **Standards for Plastics and Rubber:** For wiper blades, washer fluid hoses, and other plastic/rubber components, standards related to material durability, UV resistance, ozone resistance, and chemical resistance (to washer fluid) would apply. These are often industry-specific or national standards.

• **Standards for Motors and Actuators:** Standards related to the performance, reliability, and safety of electric motors and actuators would be relevant for the wiper motor.

**Key Considerations for Wiper and Washer Systems:**

• **Visibility:** The primary function is to ensure driver visibility. Failure to operate effectively in adverse weather can lead to accidents.

• **Distraction:** Unexpected activation or erratic behavior can distract the driver.

• **Electrical Safety:** As part of the vehicle's electrical system, it must comply with electrical safety regulations.

• **Environmental Factors:** Components must withstand harsh environmental conditions (temperature, moisture, UV, road salt).

• **Durability and Reliability:** The system needs to be reliable over the vehicle's lifespan.

• **User Interface:** Controls must be intuitive and easy to operate without taking the driver's attention away from the road.

**In summary, the design and safety of a Wiper and Washer System are governed by a layered approach:**

1. **Mandatory Vehicle Safety Regulations (UNECE, FMVSS, etc.)** set the baseline requirements.

2. **Functional Safety Standards (ISO 26262)** provide the framework for managing risks associated with system failures.

3. **EMC Standards (UNECE R10, ISO 11452, etc.)** ensure proper electromagnetic behavior.

4. **Electrical and Component Standards (ISO 16750, SAE, IEC)** guide the design and testing of individual parts.

When designing a wiper and washer system, engineers must consult the latest versions of these regulations and standards and perform thorough risk assessments to ensure the system meets all applicable safety requirements.

2.2 Functional Behaviour at Vehicle Level

*Clause: 5.4.1 b)*

The Wiper and Washer System is a crucial safety feature that ensures driver visibility in various weather conditions. Its behavior during normal vehicle operation is designed to be intuitive and responsive, with different modes catering to specific scenarios.

Here's a breakdown of its behavior during normal vehicle operation, including key operating modes:

Normal Vehicle Operation:

In general, the Wiper and Washer System operates based on user input (stalk controls) and, in some cases, automatic sensing (rain sensors). The primary goal is to clear the windshield of water, snow, or debris to maintain optimal visibility.

Key Operating Modes:

**1. Standby Mode (Vehicle Stationary, Ignition On, No Rain Detected):**

• **Behavior:** In this mode, the wipers are typically in their parked position, resting at the bottom of the windshield. The washer fluid pump is inactive. The system is ready to be activated by the driver.

• **User Interaction:** The driver can manually activate the wipers and washers using the dedicated stalk controls.

• **Automatic Activation (if equipped):** If the vehicle has an automatic rain sensor and it's not detecting any precipitation, the system remains in standby.

**2. Manual Operation Mode (Driver Activated):**

This is the most common mode of operation and is entirely controlled by the driver.

• **Intermittent Wipe:**

• **Behavior:** The wipers sweep across the windshield at pre-set intervals. The frequency of these intervals is usually adjustable by the driver (e.g., low, medium, high). This is ideal for light rain or mist.

• **User Interaction:** The driver selects the intermittent setting on the wiper stalk and adjusts the interval speed.

• **Low Speed Continuous Wipe:**

• **Behavior:** The wipers move continuously across the windshield at a slow, steady speed. This is suitable for moderate rain.

• **User Interaction:** The driver selects the low speed continuous setting on the wiper stalk.

• **High Speed Continuous Wipe:**

• **Behavior:** The wipers move continuously across the windshield at a faster speed. This is used for heavy rain or when driving at higher speeds where wind can push more water onto the windshield.

• **User Interaction:** The driver selects the high speed continuous setting on the wiper stalk.

• **Washer Operation:**

• **Behavior:** When the washer button is pressed, the washer fluid pump activates, spraying fluid onto the windshield. Simultaneously, the wipers typically activate for a few sweeps to distribute the fluid and clear the debris. The duration of the washer spray and the number of wiper sweeps are usually pre-programmed.

• **User Interaction:** The driver presses and holds the washer button.

**3. Automatic Operation Mode (Rain Sensor Activated - if equipped):**

• **Behavior:** The rain sensor, typically located on the windshield near the rearview mirror, detects the presence and intensity of rain. The system then automatically controls the wiper speed and frequency.

• **Light Rain:** The wipers will operate in intermittent mode with a slower interval.

• **Moderate Rain:** The wipers will switch to a faster intermittent interval or low-speed continuous wipe.

• **Heavy Rain:** The wipers will engage in high-speed continuous wipe.

• **No Rain:** The wipers will return to their parked position.

• **User Interaction:** The driver typically activates the automatic mode via a dedicated setting on the wiper stalk. They may also have some control over the sensitivity of the rain sensor.

**4. Driving Mode (Vehicle in Motion):**

• **Behavior:** The wiper and washer system's behavior in driving mode is largely dictated by the other modes described above (Manual or Automatic). However, some systems might have subtle adjustments:

• **Speed Compensation:** Some advanced systems might slightly increase wiper speed or frequency as vehicle speed increases, especially in automatic mode, to compensate for increased water accumulation.

• **Washer Fluid Management:** The system will ensure sufficient washer fluid is available for effective cleaning.

• **User Interaction:** Primarily driver-controlled or automatically managed by the rain sensor.

**5. Charging Mode (Electric Vehicles - EV):**

• **Behavior:** During charging, the wiper and washer system generally behaves the same as in Standby mode when the vehicle is stationary. There's no specific "charging mode" that alters its fundamental operation. The system is available for use if needed, but it's not actively engaged unless the driver initiates it or rain is detected.

• **User Interaction:** Driver-controlled or automatically managed by the rain sensor.

**6. Fault Mode:**

• **Behavior:** If the Wiper and Washer System detects a malfunction, it will enter a fault mode. This can manifest in several ways:

• **Wipers Inoperative:** The wipers may not move at all, or they might move erratically.

• **Washer Inoperative:** The washer fluid pump may not activate.

• **Warning Light/Message:** A dashboard warning light or a message on the instrument cluster will typically illuminate, indicating a system fault.

• **Limited Functionality:** In some cases, the system might revert to a basic, single-speed operation as a fallback.

• **User Interaction:** The driver will be alerted to the fault and should consult the vehicle's owner's manual for troubleshooting or seek professional service. The system will not operate as intended.

**In summary, the Wiper and Washer System is designed to be a proactive and reactive safety feature. It prioritizes driver visibility by responding to manual inputs and, in advanced systems, environmental conditions. The system's behavior is generally consistent across different vehicle states, with the primary variations occurring based on user control and the presence of rain.**

2.3 Required Quality, Performance, and Availability

*Clause: 5.4.1 c)*

Here are non-functional requirements for a Wiper and Washer System, specified with examples for each category:

Non-Functional Requirements for Wiper and Washer System

These requirements define the quality attributes of the system, focusing on how well it performs its functions rather than what specific functions it performs.

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1. Accuracy

Accuracy defines the degree to which the system's output or behavior conforms to the intended or specified value.

• **Requirement:** The wiper speed control shall maintain the selected speed within a specified tolerance.

• **Example:** The wiper motor speed shall be maintained within **±5%** of the commanded speed across the operating temperature range.

• **Requirement:** The washer fluid pump activation shall deliver a consistent volume of fluid.

• **Example:** The washer fluid pump shall deliver **15ml ± 2ml** of fluid per activation cycle.

• **Requirement:** The wiper position sensing shall accurately report the current wiper blade position.

• **Example:** The wiper position sensor shall report the wiper blade's position with an accuracy of **±2 degrees** relative to the parked position.

• **Requirement:** The rain sensor sensitivity shall accurately detect varying levels of precipitation.

• **Example:** The rain sensor shall reliably detect precipitation levels from a light mist (e.g., 0.1 mm/hr) to heavy rain (e.g., 50 mm/hr) with a detection accuracy of **±10%** of the measured precipitation rate.

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2. Response Time

Response time defines the time taken for the system to react to an input or event and produce an output or initiate an action.

• **Requirement:** The system shall respond to user activation of the wiper control within a specified time.

• **Example:** Upon activation of the wiper control (e.g., moving the stalk to the first speed setting), the wipers shall begin moving within **≤ 200ms**.

• **Requirement:** The system shall respond to rain detection and adjust wiper speed accordingly.

• **Example:** Upon detection of a significant increase in precipitation by the rain sensor, the wiper speed shall adjust to the next higher setting within **≤ 500ms**.

• **Requirement:** The system shall respond to user activation of the washer function.

• **Example:** Upon activation of the washer button, the washer pump shall activate and spray fluid within **≤ 150ms**.

• **Requirement:** The system shall respond to changes in vehicle speed affecting wiper operation.

• **Example:** When the vehicle speed drops below a threshold (e.g., 5 km/h) and the wipers are on a speed setting dependent on vehicle speed, the wiper speed shall adjust within **≤ 300ms**.

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3. Reliability

Reliability defines the probability that the system will perform its intended function without failure for a specified period of time under specified conditions.

• **Requirement:** The wiper motor shall operate without failure for a defined operational lifespan.

• **Example:** The wiper motor shall have a reliability of **99.9%** over **100,000 operational cycles**.

• **Requirement:** The washer pump shall operate without failure during its expected service life.

• **Example:** The washer pump shall have a reliability of **99.95%** over **5 years of typical use** (defined as X activations per year).

• **Requirement:** The rain sensor shall consistently and accurately detect rain without false positives or negatives.

• **Example:** The rain sensor shall have a reliability of **99.99%** in detecting actual precipitation events and **99.999%** in *not* triggering on non-precipitation events (e.g., water splashes from other vehicles) over **10 years of operation**.

• **Requirement:** The control module shall operate without failure under various environmental conditions.

• **Example:** The wiper and washer control module shall have a reliability of **99.99%** over **10 years of operation** in automotive environmental conditions (temperature, vibration, humidity).

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4. MTBF (Mean Time Between Failures)

MTBF is a measure of the average time that a system or component operates before it fails. It's a key indicator of reliability.

• **Requirement:** The wiper motor shall have a specified MTBF.

• **Example:** The wiper motor shall have an MTBF of **≥ 50,000 operating hours**.

• **Requirement:** The washer pump shall have a specified MTBF.

• **Example:** The washer pump shall have an MTBF of **≥ 100,000 operating hours**.

• **Requirement:** The rain sensor shall have a specified MTBF.

• **Example:** The rain sensor shall have an MTBF of **≥ 200,000 operating hours**.

• **Requirement:** The control module shall have a specified MTBF.

• **Example:** The wiper and washer control module shall have an MTBF of **≥ 150,000 operating hours**.

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5. Availability

Availability defines the degree to which the system is operational and accessible when required. It's often expressed as a percentage.

• **Requirement:** The wiper and washer system shall be available for operation when the vehicle is in use.

• **Example:** The wiper and washer system shall have an availability of **99.99%** during vehicle operation. This accounts for scheduled maintenance and very brief, infrequent failures.

• **Requirement:** The system shall be available for immediate use upon vehicle startup.

• **Example:** The wiper and washer system shall be fully operational and responsive within **1 second** of the vehicle's ignition being turned on.

• **Requirement:** The system shall remain available even in degraded modes.

• **Example:** In the event of a rain sensor failure, the system shall still allow for manual operation of wipers and washers with **100% availability** for manual control.

• **Requirement:** The system shall be available for diagnostic checks.

• **Example:** The system shall be available for diagnostic communication and reporting of fault codes **99.999%** of the time when the vehicle's diagnostic port is accessed.

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**Note:** The specific values for these non-functional requirements will depend heavily on the intended application (e.g., passenger car, commercial vehicle, high-performance sports car), regulatory requirements, and cost considerations. These examples provide a framework for defining such requirements.

2.4 Constraints Regarding the Item

*Clause: 5.4.1 d)*

Here's a breakdown of functional, environmental, and dependency constraints for a Wiper and Washer System, categorized for clarity:

Wiper and Washer System Constraints

1. Functional Constraints (What the system \*must do\* and \*how\*)

• **Wiper Operation:**

• **Speed Control:** Must provide multiple distinct wiping speeds (e.g., low, high, intermittent).

• **Park Position:** Must reliably return the wiper blades to a designated "park" position when deactivated.

• **Wipe Pattern:** Must cover a defined area of the windshield for effective visibility.

• **Intermittent Wipe Interval:** Must allow for adjustable or pre-set intermittent wiping intervals.

• **Automatic Operation (Optional):** If equipped with rain sensing, must activate and adjust wiper speed/frequency based on detected rainfall intensity.

• **Washer Activation:** Must spray washer fluid onto the windshield upon activation.

• **Washer Fluid Delivery:** Must deliver a sufficient amount of fluid to effectively clean the windshield.

• **Washer Fluid Level Monitoring (Optional):** Must indicate when the washer fluid reservoir is low.

• **Synchronization (Multi-wiper systems):** If multiple wiper arms are present, they must operate in a synchronized manner.

• **Obstruction Detection/Protection (Optional):** May need to detect and react to obstructions (e.g., ice, branches) to prevent damage to the motor or wiper arms.

• **Self-Cleaning (Optional):** Some systems might have a self-cleaning function for the washer nozzles.

• **Washer System:**

• **Nozzle Aiming:** Washer nozzles must be aimed to effectively spray fluid onto the windshield.

• **Fluid Flow Rate:** Must deliver a consistent and adequate flow rate of washer fluid.

• **Pump Operation:** The washer pump must operate reliably when activated.

• **Fluid Reservoir Capacity:** The reservoir must hold a sufficient volume of fluid for typical usage.

• **User Interface:**

• **Control Accessibility:** Controls (stalk, buttons) must be easily accessible and intuitive for the driver.

• **Feedback:** May provide visual or auditory feedback for system status (e.g., washer fluid low indicator).

2. Environmental Constraints (Conditions the system must withstand and operate within)

• **Operating Temperature Range:**

• **Ambient Temperature:** Must operate reliably within the vehicle's expected ambient temperature range (e.g., -40°C to +85°C).

• **Extreme Cold:** Must not freeze or become brittle in sub-zero temperatures. Washer fluid formulation is also a related constraint.

• **Extreme Heat:** Must not overheat or degrade materials in high temperatures.

• **Humidity:**

• **High Humidity:** Must resist corrosion and electrical failures in humid environments.

• **Condensation:** Must be designed to handle condensation without compromising functionality.

• **Vibration and Shock:**

• **Vehicle Vibration:** Must withstand continuous vibration from the vehicle's operation.

• **Shock Loads:** Must tolerate occasional shock loads (e.g., driving over bumps, minor impacts).

• **Dust and Debris:**

• **Ingress Protection (IP Rating):** Components (motor, pump, switches) should have an appropriate IP rating to prevent dust and water ingress.

• **Windshield Contaminants:** Must operate effectively with various contaminants on the windshield (dirt, mud, insects, salt).

• **UV Exposure:**

• **Material Degradation:** Exterior components (wiper arms, nozzles) must resist degradation from UV radiation.

• **Water Exposure:**

• **Splash and Spray:** Must be resistant to water splashes and spray from the road and the washer system itself.

• **Submersion (Limited):** While not designed for full submersion, components may be exposed to significant water during car washes or heavy rain.

• **Electromagnetic Compatibility (EMC) / Electromagnetic Interference (EMI):**

• **EMI Susceptibility:** The system must not be unduly affected by electromagnetic interference generated by other vehicle systems (e.g., engine control unit, radio).

• **EMI Emission:** The system itself must not generate excessive EMI that could interfere with other vehicle systems.

3. Dependency Constraints (What the system relies on or interacts with)

• **Power Supply:**

• **Voltage:** Must operate within the vehicle's nominal electrical system voltage (e.g., 12V DC).

• **Current Draw:** Must not exceed the available current capacity of the vehicle's electrical system or fuse.

• **Power Fluctuations:** Must tolerate minor voltage fluctuations common in automotive electrical systems.

• **Battery State:** May need to consider the vehicle's battery state (e.g., low battery might limit intermittent wiper operation).

• **Vehicle Electrical System:**

• **Wiring Harness:** Must integrate seamlessly with the vehicle's existing wiring harness.

• **Connectors:** Must use compatible and reliable connectors.

• **Grounding:** Requires proper grounding to the vehicle chassis.

• **CAN Bus (Optional):** If integrated with modern vehicle networks, it may need to communicate via CAN bus for control and diagnostics.

• **Vehicle Body and Structure:**

• **Mounting Points:** Requires secure and stable mounting points on the vehicle body.

• **Clearance:** Wiper arms and blades must have sufficient clearance to sweep the windshield without hitting other vehicle components (hood, mirrors, A-pillars).

• **Aerodynamics:** Wiper blade design and arm pressure can be influenced by vehicle aerodynamics.

• **Washer Fluid:**

• **Fluid Type:** Must be compatible with the chosen washer fluid (e.g., not corrosive to seals or plastics).

• **Freezing Point:** The washer fluid's freezing point is a critical dependency for operation in cold weather.

• **Driver Input:**

• **Control Signals:** Relies on the driver's input via the control stalk or buttons.

• **Other Vehicle Systems (for advanced features):**

• **Rain Sensor:** If equipped with automatic wipers, it depends on the rain sensor's output.

• **Headlight Washers:** If integrated, it depends on the headlight washer system's activation.

• **Vehicle Speed Sensor:** Some advanced wiper systems might adjust speed based on vehicle speed.

• **Maintenance and Serviceability:**

• **Accessibility for Replacement:** Components like wiper blades and washer fluid should be easily accessible for replacement and refilling.

• **Diagnostic Capabilities (Optional):** May require diagnostic ports or interfaces for troubleshooting.

This comprehensive list highlights the multifaceted nature of designing and implementing a reliable Wiper and Washer System within the complex environment of an automobile.

2.5 Potential Consequences of Behavioural Shortfalls

*Clause: 5.4.1 e)*

A failure or incorrect behavior of the Wiper and Washer System, while seemingly minor, can indeed contribute to hazards that feed into a Hazard Analysis and Risk Assessment (HARA). Here's a breakdown of potential hazards, categorized by their impact, and how they might relate to fire, loss of propulsion, or electric shock:

Potential Hazards of Wiper and Washer System Failure/Malfunction:

**I. Reduced Visibility Leading to Accidents (Primary Hazard)**

This is the most direct and significant hazard. The Wiper and Washer System's primary function is to maintain clear visibility for the driver.

• **Failure Mode:** Wipers not operating, wipers operating intermittently, wipers operating at the wrong speed, washer fluid not spraying, washer fluid spraying incorrectly (e.g., only on the hood, not the windshield).

• **Consequences:**

• **Collision with other vehicles:** Inability to see approaching traffic, pedestrians, or obstacles.

• **Collision with stationary objects:** Inability to see road edges, barriers, signs, or parked vehicles.

• **Loss of control:** Sudden loss of visibility can lead to abrupt steering or braking, potentially causing a skid or rollover.

• **Failure to react to hazards:** Inability to see sudden road changes, debris, or animals.

• **Reduced situational awareness:** Driver becomes solely focused on trying to see, neglecting other critical driving tasks.

**II. Electrical System Issues (Potential for Fire and Electric Shock)**

The Wiper and Washer System is an electrical component and can contribute to electrical hazards.

• **Failure Mode:** Short circuits in wiring, faulty motor, faulty control module, water ingress into electrical components.

• **Consequences:**

• **Fire Hazard:**

• **Overheating:** A short circuit or a stalled motor can draw excessive current, leading to overheating of wires and components. This can ignite surrounding materials (insulation, dust, debris).

• **Arcing:** Faulty connections or damaged insulation can cause electrical arcing, which generates intense heat and can ignite nearby flammable materials.

• **Component Failure:** A malfunctioning motor or control module can overheat and fail catastrophically, potentially leading to a fire.

• **Electric Shock Hazard:**

• **Damaged Insulation:** If wiring insulation is compromised (e.g., due to abrasion, heat, or age), exposed live wires can pose a shock risk to anyone touching them, especially during maintenance or if the vehicle is submerged.

• **Water Ingress:** If water enters the electrical housing of the wiper motor or control module, it can create conductive paths, leading to short circuits and potential shock hazards if the system is energized.

**III. Mechanical System Issues (Indirectly Affecting Propulsion)**

While the wiper system doesn't directly control propulsion, its failure can indirectly lead to situations where propulsion is compromised.

• **Failure Mode:** Wiper motor seizing, wiper arm detaching, wiper blade becoming loose.

• **Consequences:**

• **Loss of Propulsion (Indirect):**

• **Driver Distraction:** A malfunctioning wiper system (e.g., a loud grinding noise, a wiper arm flailing erratically) can be a significant distraction. If the driver is overly focused on the malfunctioning system, they might miss critical cues for acceleration or deceleration, leading to a perceived "loss of propulsion" in a dynamic situation.

• **Mechanical Interference:** In rare cases, a severely malfunctioning wiper mechanism could physically interfere with other engine bay components, though this is highly unlikely to directly cause a loss of propulsion.

• **Emergency Maneuvers:** If reduced visibility forces an emergency maneuver, the driver might overreact, leading to a stall or other issues that could be perceived as a loss of propulsion.

**IV. Water/Fluid Related Hazards**

• **Failure Mode:** Washer fluid pump failure, clogged nozzles, leaks in the washer fluid reservoir or lines.

• **Consequences:**

• **Reduced Visibility:** As mentioned in Section I, the inability to clear the windshield of dirt, bugs, or salt spray directly impacts visibility.

• **Corrosion:** Leaking washer fluid (which often contains alcohol or other chemicals) can drip onto engine components or electrical connectors, potentially leading to corrosion over time, which could indirectly contribute to electrical issues or mechanical failures.

• **Contamination:** If the washer fluid reservoir is contaminated, it could lead to clogged nozzles or damage to the pump.

**V. Driver Annoyance and Fatigue**

• **Failure Mode:** Intermittent operation, unusual noises, constant on/off cycling.

• **Consequences:**

• **Driver Fatigue:** Constant annoyance from a malfunctioning system can lead to driver fatigue, which in turn increases the risk of accidents.

• **Reduced Concentration:** Similar to distraction, a persistently annoying system can reduce a driver's ability to concentrate on the road.

How These Feed into HARA:

For each of these potential hazards, a HARA process would involve:

1. **Hazard Identification:** Listing the specific failure modes and their direct consequences (e.g., "Wiper motor fails to operate," leading to "Reduced visibility").

2. **Hazard Classification:** Categorizing the severity of the hazard (e.g., "Catastrophic" for a multi-vehicle collision due to zero visibility, "Minor" for driver annoyance).

3. **Exposure Analysis:** Estimating the likelihood of the hazard occurring (e.g., how often do wipers fail, how often is visibility compromised by weather).

4. **Controllability Analysis:** Assessing how easily the driver or system can mitigate the hazard (e.g., can the driver pull over safely, are there redundant systems).

5. **Risk Assessment:** Combining severity, exposure, and controllability to determine the overall risk level.

6. **Safety Goal Definition:** Establishing safety goals to reduce the risk to an acceptable level (e.g., "Prevent collisions due to loss of visibility caused by wiper system failure").

7. **Safety Requirements Derivation:** Defining specific requirements for the wiper and washer system to meet the safety goals (e.g., "The wiper system shall operate reliably in all specified environmental conditions," "The electrical components shall be protected against short circuits and overheating").

**In summary, while the Wiper and Washer System might seem like a simple comfort feature, its failure can cascade into significant safety concerns, including direct accident risks, potential electrical fires, and indirect impacts on vehicle operation. These are precisely the types of hazards that a thorough HARA process aims to identify and mitigate.**

2.6 Capabilities of the Actuators (or Assumed Capabilities)

*Clause: 5.4.1 f)*

The Wiper and Washer System, while not a primary safety system in the same vein as airbags or ABS, can contribute to safety by improving driver visibility. Its actuation speed and effectiveness are crucial for its role in HARA (Hazard Analysis and Risk Assessment), particularly for assessing **Severity** and **Controllability**.

Here's a breakdown of how quickly and effectively the Wiper and Washer System can actuate safety responses, along with their implications for HARA:

Wiper and Washer System Actuation Speed and Effectiveness for Safety Responses

The actuation of a wiper and washer system is generally characterized by two main phases:

1. **Wiper Activation:** This involves the motor starting and the wiper blades moving across the windshield.

2. **Washer Fluid Dispensing:** This involves the pump activating and fluid being sprayed onto the windshield.

**Typical Actuation Speeds:**

• **Wiper Motor Activation & Initial Sweep:**

• **Speed:** **100ms to 500ms (0.1 to 0.5 seconds)** from the command being issued to the wipers starting their first sweep.

• **Effectiveness:** This is the time it takes for the motor to overcome inertia and begin moving the blades. The effectiveness here is about clearing initial obstructions.

• **Full Wiper Sweep Cycle:**

• **Speed:** A single sweep (one pass across the windshield) typically takes **0.5 to 1.5 seconds**, depending on the speed setting.

• **Effectiveness:** This is the primary mechanism for clearing rain, snow, or debris. Multiple sweeps are needed for significant clearing.

• **Washer Fluid Pump Activation & Dispensing:**

• **Speed:** **200ms to 800ms (0.2 to 0.8 seconds)** from the command to the fluid being sprayed. This includes pump priming and fluid travel to the nozzles.

• **Effectiveness:** This is crucial for removing stubborn dirt, insects, or salt spray that wipers alone cannot handle. The effectiveness depends on the pressure and coverage of the spray.

• **Combined Wiper and Washer Activation (Typical Scenario):**

• **Speed:** When activated together, the system will typically start dispensing fluid shortly after the wipers begin their initial sweep. The first effective clearing action (fluid on glass, wipers moving) might be around **0.5 to 1.0 seconds**.

• **Effectiveness:** This combined action is the most effective for immediate visibility improvement in moderate to heavy precipitation or when the windshield is dirty.

**Important Considerations for HARA:**

• **"Safety Response" Definition:** For the wiper and washer system, the "safety response" is **restoring or improving driver visibility**. It's not an instantaneous "contactor opens" type of response.

• **Triggering Mechanism:** The system is typically triggered by rain sensors or manual driver input. The time for the sensor to detect rain and send a signal is also a factor, but this is usually considered part of the *detection* phase, not the *actuation* phase of the system itself.

• **System State:** The speed can be affected by whether the system is already "warm" (motor has been used recently) or if it's a cold start.

• **Environmental Factors:** Extreme cold can affect fluid viscosity and pump performance.

Application in HARA for Severity/Controllability

The actuation speed and effectiveness of the Wiper and Washer System are critical when assessing its contribution to mitigating hazards related to **Severity** and **Controllability**.

**1. Severity:**

• **How it applies:** The Wiper and Washer System directly impacts the **Severity** of a hazard by reducing the likelihood of an accident caused by poor visibility. If the system acts quickly and effectively, it can prevent a situation from escalating to a severe outcome.

• **Example:**

• **Hazard:** Loss of visibility due to heavy rain.

• **Severity without Wiper/Washer:** High (e.g., inability to see road markings, other vehicles, leading to a collision).

• **Severity with effective Wiper/Washer:** Reduced. The system clears the rain within a few seconds, allowing the driver to regain sufficient visibility to react and avoid the hazard.

• **HARA Assessment:**

• **Fast and Effective Actuation (e.g., <1 second for initial clearing):** Contributes to a **lower Severity rating** for visibility-related hazards. The system is considered a good mitigation measure.

• **Slow or Ineffective Actuation (e.g., wipers struggle, washer fluid is weak):** Contributes to a **higher Severity rating**. The system is not an effective mitigation.

**2. Controllability:**

• **How it applies:** Controllability refers to the driver's ability to maintain control of the vehicle in a hazardous situation. The Wiper and Washer System enhances controllability by ensuring the driver has a clear view of the road, steering inputs, and potential obstacles.

• **Example:**

• **Hazard:** Sudden onset of fog or heavy spray from a passing truck.

• **Controllability without Wiper/Washer:** Low. The driver cannot see where they are going, making it difficult to steer or brake appropriately.

• **Controllability with effective Wiper/Washer:** Improved. The system quickly clears the obstruction, allowing the driver to maintain steering control and make necessary adjustments.

• **HARA Assessment:**

• **Fast and Effective Actuation:** Contributes to a **higher Controllability rating**. The driver can react and maintain control because their vision is restored promptly.

• **Slow or Ineffective Actuation:** Contributes to a **lower Controllability rating**. The driver's ability to control the vehicle is compromised due to prolonged poor visibility.

**In summary, for HARA purposes:**

The Wiper and Washer System's actuation speed is measured in **hundreds of milliseconds to a couple of seconds** for initial clearing. Its effectiveness is judged by its ability to **restore driver visibility**.

• **Fast and effective actuation** leads to a **lower Severity** rating for visibility-related hazards and a **higher Controllability** rating, as the driver can quickly perceive and react to the environment.

• **Slow or ineffective actuation** leads to a **higher Severity** rating and a **lower Controllability** rating, as the driver's ability to manage the situation is significantly impaired.

When performing HARA, the specific actuation times and the expected clearing performance under various conditions (light rain, heavy rain, snow, dirt) are considered to determine the effectiveness of this system as a safety measure.

3. Boundary of the Item, Interfaces, and Interaction Assumptions

*Clause: 5.4.2*

3.1 Elements of the Item

*Clause: 5.4.2 a)*

Let's break down the Wiper and Washer System and define what's IN and OUT of scope.

Wiper and Washer System: In Scope Components

This list focuses on the core functionality of the wiper and washer system, including its control, sensing, and actuation.

Hardware Components (In Scope):

• **Wiper Motor:** The electric motor that drives the wiper arms.

• **Wiper Arms:** The mechanical arms that hold the wiper blades and sweep across the windshield.

• **Wiper Blades:** The rubber or silicone components that make contact with the windshield to clear water and debris.

• **Washer Pump Motor:** The electric motor that pumps washer fluid from the reservoir.

• **Washer Nozzles:** The outlets that spray washer fluid onto the windshield.

• **Wiper Control Module (or integrated into a larger Body Control Module - BCM):** This is the central processing unit responsible for managing the wiper and washer functions. It could be a dedicated MCU or a section of a larger MCU.

• **Microcontroller Unit (MCU):** The brain of the control module, executing the software logic.

• **Motor Drivers/Relays:** Electronic components that control the power flow to the wiper motor and washer pump motor.

• **Power Management Circuits:** Components that regulate and distribute power to the system.

• **Wiper Park Switch/Sensor:** A sensor (often mechanical or Hall effect) that detects when the wiper arms are in their "parked" position, allowing the system to stop the motor at the correct location.

• **Rain Sensor (if equipped):** A sensor that detects the presence and intensity of rain on the windshield. This is a key input for automatic wiper operation.

• **Washer Fluid Level Sensor (if equipped):** A sensor that monitors the amount of washer fluid in the reservoir.

• **Wiring Harness:** The electrical connections that link all the components together.

• **Fuses and Relays:** Protective devices for the electrical circuits.

• **Washer Fluid Reservoir:** The container holding the washer fluid.

Software Modules/Functions (In Scope):

• **Wiper Control Logic:**

• **Speed Control:** Managing different wiper speeds (intermittent, low, high).

• **Intermittent Wiper Timing:** Implementing the delay intervals for intermittent operation.

• **Wiper Park Functionality:** Ensuring the wipers stop in the correct parked position.

• **Wiper Activation/Deactivation:** Responding to user inputs (stalk switches).

• **Washer Control Logic:**

• **Washer Pump Activation:** Turning the washer pump on and off based on user input.

• **Washer Fluid Level Monitoring (if sensor present):** Triggering warnings or disabling the system when fluid is low.

• **Rain Sensing Logic (if sensor present):**

• **Rain Detection:** Interpreting signals from the rain sensor.

• **Automatic Wiper Activation/Speed Adjustment:** Controlling wipers based on detected rain intensity.

• **Wiper/Washer Coordination:** Potentially integrating washer activation with wiper operation for optimal cleaning.

• **Diagnostic Routines:**

• **Fault Detection:** Identifying issues within the wiper and washer system (e.g., motor failure, sensor malfunction).

• **Error Reporting:** Communicating detected faults to other vehicle systems (e.g., dashboard warning lights).

• **User Interface Interaction:**

• **Input Processing:** Reading signals from the wiper/washer stalk switches.

• **Output Control:** Activating indicators or warnings on the dashboard (e.g., low washer fluid light).

• **Communication Protocols (if integrated into a network):**

• **CAN Bus Communication:** If the wiper/washer module communicates with other ECUs on the vehicle's CAN bus for status updates or commands.

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Wiper and Washer System: OUTSIDE Scope

These components are related to the overall vehicle but are not directly part of the *operation* or *control* of the wiper and washer system itself.

Hardware Components (OUTSIDE Scope):

• **Windshield:** While the wipers and washers act upon it, the windshield itself is not part of the system's hardware.

• **Washer Fluid:** The fluid itself is a consumable, not a system component.

• **Vehicle Power Supply (Battery, Alternator):** While essential for operation, these are general vehicle power sources, not specific to the wiper/washer system.

• **Vehicle Electrical System (General Wiring, Junction Boxes):** Unless a specific junction box is dedicated solely to the wiper/washer system, general vehicle electrical infrastructure is out of scope.

• **Dashboard/Instrument Cluster (except for warning lights/indicators related to the system):** The display of information is a separate system.

• **Vehicle Body/Chassis:** The physical mounting points for the system.

• **User Interface Controls (Stalk Switches themselves, if considered part of the steering column assembly):** While the system *receives input* from these, the physical switches and their integration into the steering column are often considered part of a broader interior/steering column system. However, the *signals* they generate are in scope.

• **Headlight Washer System (if separate):** If the headlight washers are a distinct system with their own pump, reservoir, and control, they would be out of scope for the *windshield* wiper and washer system.

• **Heated Wiper System Components (if present):** Heating elements or their dedicated control modules would be a separate system.

• **Advanced Driver-Assistance Systems (ADAS) Cameras/Sensors (unless directly integrated for wiper control):** While some ADAS systems might use the windshield, their primary function is not wiper control.

Software Modules/Functions (OUTSIDE Scope):

• **General Vehicle Diagnostics Software:** Broader diagnostic tools that can access all ECUs.

• **Infotainment System Software:** User interface for media, navigation, etc.

• **Engine Control Unit (ECU) Software:** Managing engine performance.

• **Transmission Control Unit (TCU) Software:** Managing gear shifts.

• **Braking System Software:** ABS, ESC, etc.

• **Lighting Control Software (general):** Controlling headlights, taillights, etc.

• **Climate Control System Software:** Managing HVAC.

• **User Interface Software for other vehicle functions:** Any software not directly related to controlling or monitoring the wiper and washer system.

• **Over-the-Air (OTA) Update Management Software (for the entire vehicle):** While the wiper/washer software might be updated via OTA, the general OTA update infrastructure is out of scope.

• **Cybersecurity Software for the entire vehicle:** General security measures.

**In essence, anything that is not directly involved in the generation of motion for the wipers, the spraying of fluid, the sensing of rain or fluid level, or the control logic that orchestrates these actions is considered out of scope.**

3.2 Assumptions Concerning Effects on the Vehicle

*Clause: 5.4.2 b)*

The Wiper and Washer System, while seemingly simple, plays a crucial role in vehicle safety and driver comfort. Its behavior, or lack thereof, can have significant impacts on both the vehicle and the driver. Here's a breakdown of assumed impacts:

Impacts on the Driver:

**Positive Impacts (When the System Functions Correctly):**

• **Enhanced Visibility and Reduced Distraction:**

• **Clearer View:** Properly functioning wipers remove rain, snow, and debris, allowing the driver to see the road, other vehicles, pedestrians, and hazards clearly.

• **Reduced Eye Strain:** The driver doesn't have to squint, strain their eyes, or constantly wipe the windshield manually, leading to less fatigue on longer journeys.

• **Focus on Driving:** With clear visibility, the driver can concentrate on steering, braking, and anticipating traffic, rather than being preoccupied with maintaining a clear view.

• **Improved Comfort and Reduced Stress:**

• **Pleasant Driving Experience:** Driving in adverse weather becomes less stressful and more comfortable when the windshield is clear.

• **Sense of Control:** The driver feels more in control of the vehicle when they can see their surroundings effectively.

• **Reduced Anxiety:** The fear of not being able to see during sudden downpours or snowstorms is alleviated.

• **Timely Information and Warnings (if equipped with advanced features):**

• **Rain Sensor Activation:** Automatic wipers detect rain and activate without driver intervention, providing immediate clearing.

• **Washer Fluid Level Warnings:** Low washer fluid warnings alert the driver to refill, preventing a situation where they can't clear the windshield when needed.

• **Wiper Blade Condition Warnings (less common but possible):** Alerts about worn wiper blades would prompt replacement before performance degrades.

**Negative Impacts (When the System Malfunctions or Fails):**

• **Severely Impaired Visibility and Increased Risk of Accidents:**

• **Blind Spots:** Inoperative wipers can create large blind spots, making it impossible to see approaching vehicles, pedestrians, or road edges.

• **Sudden Hazards:** The driver might not see sudden obstacles like fallen branches, debris, or animals, leading to evasive maneuvers or collisions.

• **Reduced Reaction Time:** Limited visibility drastically reduces the driver's reaction time to changing road conditions or other vehicles' actions.

• **Disorientation:** In heavy precipitation, a completely obscured windshield can lead to disorientation and a feeling of being lost.

• **Increased Driver Frustration and Stress:**

• **Annoyance and Impatience:** The inability to clear the windshield can be incredibly frustrating, especially in heavy traffic or during important journeys.

• **Panic and Anxiety:** In critical situations, the lack of visibility can induce panic and anxiety, leading to poor decision-making.

• **Physical Discomfort:** Manual wiping can be tiring and awkward, especially if the wipers are not working at all.

• **Potential for Driver Error and Reckless Behavior:**

• **Aggressive Driving:** Frustrated drivers might resort to aggressive maneuvers to try and compensate for poor visibility.

• **Ignoring Warnings:** If the system is constantly malfunctioning, the driver might start ignoring any warnings it does provide.

• **Legal and Financial Consequences:**

• **Traffic Violations:** Driving with impaired visibility due to faulty wipers can lead to traffic tickets and fines.

• **Increased Insurance Premiums:** Accidents caused by poor visibility can result in higher insurance costs.

Impacts on the Vehicle:

**Positive Impacts (When the System Functions Correctly):**

• **Reduced Wear and Tear on Windshield:** Properly functioning wipers with good blades clean the windshield without scratching or damaging the glass.

• **Optimal Washer Fluid Distribution:** The washer system effectively sprays fluid to lubricate the windshield and assist the wipers, preventing dry streaks and potential damage.

• **Preventing Damage from Debris:** Wipers can clear away small debris that could otherwise scratch the windshield over time.

**Negative Impacts (When the System Malfunctions or Fails):**

• **Damage to Windshield:**

• **Scratches and Scuffs:** Worn or malfunctioning wiper blades can drag debris across the windshield, causing permanent scratches.

• **Cracks:** In extreme cases, the force of a stuck wiper arm or the impact of debris on a dirty windshield can lead to cracks.

• **Damage to Wiper Motor and Linkage:**

• **Overheating:** A seized wiper motor or a jammed linkage can overheat and burn out, requiring expensive repairs.

• **Bent or Broken Linkage:** If the wipers are forced to operate against an obstruction, the linkage mechanism can bend or break.

• **Damage to Washer System Components:**

• **Clogged Nozzles:** If the washer fluid is not used regularly or if the fluid is contaminated, the nozzles can become clogged.

• **Pump Failure:** A faulty pump can lead to no washer fluid being dispensed.

• **Electrical System Issues:**

• **Short Circuits:** Damaged wiring or faulty components within the wiper system can cause short circuits, potentially affecting other electrical systems in the vehicle.

• **Fuse Blowouts:** Overloaded circuits can blow fuses, disabling the wiper system and potentially other related functions.

• **Reduced Resale Value:** A poorly maintained or malfunctioning wiper system can be a red flag for potential buyers, negatively impacting the vehicle's resale value.

Driver Response to Warnings (Assumed):

• **Responsive Drivers:** A driver who is attentive and values safety will likely respond promptly to warnings.

• **Low Washer Fluid:** They will refill the fluid at the next convenient opportunity.

• **Wiper System Malfunction (e.g., error light):** They will seek to have the system inspected and repaired as soon as possible, especially if it's a critical component.

• **Automatic Wiper Activation (if not desired):** They might adjust the sensitivity or manually turn them off if they are activating unnecessarily.

• **Less Responsive Drivers:** Some drivers might be less attentive or prioritize other tasks.

• **Ignoring Low Fluid Warnings:** They might continue driving until the fluid runs out, only then realizing the inconvenience.

• **Delaying Repairs:** They might postpone repairs for minor wiper issues until they become more significant or until they are forced to address them.

• **Overriding Automatic Systems:** They might constantly override automatic wiper functions if they find them inconvenient, potentially leading to missed clearing opportunities.

Vehicle Coasting Safely (Assumed):

The concept of a "vehicle coasting safely" is **not directly related to the Wiper and Washer System's behavior**. Coasting refers to the vehicle's momentum carrying it forward without engine power.

However, **indirectly**, a malfunctioning wiper system could *prevent* safe coasting in certain scenarios:

• **Reduced Visibility During Coasting:** If a driver is coasting downhill or in a situation where they are intentionally not using the engine, and the wipers fail during precipitation, their visibility will be severely compromised. This could lead to them being unable to see hazards and potentially needing to brake abruptly, negating the benefits of coasting or even causing an accident.

In summary, the Wiper and Washer System is a vital safety feature. Its proper functioning ensures driver visibility, comfort, and control, while its failure can lead to significant risks for both the driver and the vehicle. Driver awareness and prompt response to any warnings are crucial for maintaining the effectiveness of this system.

3.3 Functionality Required by Other Items

*Clause: 5.4.2 c)*

The Wiper and Washer System (WWS) interacts with various other Electronic Control Units (ECUs) within a vehicle. Here's a breakdown of functions other systems might expect from the WWS, categorized by the requesting system:

Functions Other Systems Expect from the Wiper and Washer System (WWS)

**1. Vehicle Control Unit (VCU) / Powertrain Control Module (PCM) / Body Control Module (BCM):**

• **Wiper Status (On/Off, Speed, Pattern):** The VCU needs to know if the wipers are active, at what speed (low, high, intermittent), and if they are in a specific pattern (e.g., park). This is crucial for:

• **Driver Information Display:** Showing the wiper status to the driver.

• **Vehicle Dynamics Control:** In some advanced systems, wiper speed might influence aerodynamic calculations or sensor readings.

• **Power Management:** The VCU might adjust power distribution based on the load of the wiper motor.

• **System Interlocks:** Preventing certain actions (e.g., engaging cruise control at very high wiper speeds in adverse conditions).

• **Washer Fluid Level:** The VCU needs to know if the washer fluid is low or empty to:

• **Inform the Driver:** Display a warning light or message.

• **Prevent Operation:** Potentially disable the washer pump to avoid damage or ineffective operation.

• **Wiper Motor Current/Load:** Monitoring the current drawn by the wiper motor can indicate:

• **Obstruction Detection:** If the current spikes unexpectedly, it might mean the wipers are stuck or encountering an obstacle.

• **Motor Health:** Detecting abnormal current draw could signal a failing motor.

• **Washer Pump Status (On/Off):** Similar to wipers, knowing if the washer pump is active is important for diagnostics and driver feedback.

• **Wiper Park Position Signal:** Confirmation that the wipers have returned to their resting (parked) position. This is a safety and operational requirement.

• **Wiper System Fault Status:** Reporting any internal faults or errors within the WWS.

**2. Advanced Driver-Assistance Systems (ADAS) / Camera Modules / Radar Modules:**

• **Wiper Status (especially for front camera):** ADAS systems, particularly those relying on forward-facing cameras, need to know the wiper status to:

• **Compensate for Obstructions:** If wipers are active, the camera system might adjust its processing to account for potential streaks or partial obscuration.

• **Trigger Washer Operation (Automated):** In some advanced systems, the camera might detect dirt or water on the lens and trigger the washer system automatically.

• **System Readiness:** Ensure the camera's view is clear for critical ADAS functions (e.g., lane keeping, adaptive cruise control).

• **Washer Fluid Level (for camera cleaning):** If the vehicle has an automated camera cleaning system that uses the washer fluid, ADAS modules will need this information.

**3. Lighting Control Module (LCM) / Headlight Control Module:**

• **Wiper Status (especially for front sensors):** Some vehicles have rain sensors integrated with the windshield wipers. The LCM might need to know the wiper status to:

• **Activate Headlights (Automatic Headlights):** If a rain sensor is present and wipers are activated due to rain, the LCM might automatically turn on the headlights.

• **Control Washer for Headlight Cleaning:** If the vehicle has headlight washers, the LCM might coordinate their operation with the windshield wipers.

**4. Infotainment System / Human-Machine Interface (HMI):**

• **Wiper and Washer Controls:** The infotainment system provides the interface for the driver to control the WWS. It needs to:

• **Receive User Inputs:** Process commands from steering wheel buttons, touchscreens, or voice commands.

• **Display Status and Warnings:** Show wiper speed, washer fluid level, and any system faults.

• **Washer Fluid Level:** As mentioned for the VCU, the infotainment system is the primary display for this information.

**5. Gateway Module:**

• **WWS Data Aggregation and Routing:** The Gateway module acts as a central hub for communication between different ECUs. It will receive WWS status and fault information and route it to the appropriate systems.

**6. Power Management Module:**

• **Wiper Motor Current Draw:** The Power Management module might monitor the current drawn by the wiper motor to ensure it doesn't exceed the available power or to manage battery load.

**7. Diagnostic Tools:**

• **WWS Fault Codes and Data:** Diagnostic tools connect to the vehicle's network to read fault codes and live data from the WWS for troubleshooting and repair.

**8. Chassis Control Module (less common, but possible):**

• **Wiper Status for Aerodynamics:** In very high-performance vehicles, the VCU or chassis control might consider wiper speed in aerodynamic calculations, especially at high speeds.

**Key Considerations:**

• **CAN Bus Communication:** Most of these interactions happen over the vehicle's Controller Area Network (CAN) bus.

• **Signal Definitions:** Each signal exchanged between ECUs has a specific definition and format defined by the vehicle manufacturer.

• **System Complexity:** The specific functions and interactions will vary significantly based on the vehicle's make, model, year, and the level of technology implemented.

In essence, the WWS is not just a standalone system. It's an integral part of the vehicle's overall functionality, providing crucial information and receiving commands to ensure driver comfort, safety, and the proper operation of other advanced systems.

3.4 Functionality of Other Items Required by This Item

*Clause: 5.4.2 d)*

The Wiper and Washer System, while seemingly simple, relies on several other systems and data sources to function correctly and efficiently. Here's a breakdown of its dependencies:

**1. Power Supply:**

• **12V Power (Battery/Alternator):** This is the most fundamental dependency. The wiper motors, washer pump, control modules, and any associated sensors all require a stable 12V DC power supply to operate. This power is typically sourced from the vehicle's battery and regulated by the alternator when the engine is running.

**2. Vehicle Control Unit (VCU) / Body Control Module (BCM):**

• **Mode Status / User Input:** The VCU or BCM often acts as the central hub for user inputs. It receives signals from the wiper/washer stalk (e.g., off, intermittent, low, high, wash). The VCU/BCM then interprets these inputs and sends commands to the wiper/washer system's control module.

• **Vehicle Speed:** For intelligent wiper operation (e.g., adjusting intermittent speed based on vehicle speed), the VCU/BCM provides this information.

• **Ignition Status (Accessory/Run):** The VCU/BCM signals whether the vehicle's ignition is on, allowing the wiper system to operate. It might also control power to the system based on accessory mode.

• **Rain Sensor Status (if integrated):** If the vehicle has an automatic rain sensor, the VCU/BCM often processes the sensor's output and commands the wiper system accordingly.

• **Wiper System Fault Status:** The VCU/BCM might receive fault codes from the wiper system and relay them to the driver via the instrument cluster.

**3. Communication Bus (CAN Bus, LIN Bus, etc.):**

• **Data Exchange:** Modern vehicles heavily rely on communication buses for inter-system communication. The wiper and washer system's control module will likely communicate with the VCU/BCM and other relevant modules over the CAN bus. This allows for the transmission of:

• User commands from the stalk.

• Vehicle speed data.

• Rain sensor data.

• Diagnostic information.

• Status updates (e.g., wiper motor running, washer pump activated).

**4. Sensors:**

• **Rain Sensor:** This is a crucial sensor for automatic wiper operation. It detects the presence and intensity of rain on the windshield and sends this information to the VCU/BCM or directly to the wiper control module.

• **Washer Fluid Level Sensor:** This sensor monitors the amount of washer fluid in the reservoir. When the level is low, it signals the VCU/BCM or instrument cluster to alert the driver.

• **Wiper Motor Position Sensor (less common, but possible):** Some advanced systems might have sensors to detect the exact position of the wiper blades, allowing for more precise control and diagnostics.

**5. Actuators (Internal to the Wiper/Washer System but controlled by other systems):**

• **Wiper Motor:** While an actuator, its operation is dictated by commands from the control module, which in turn receives input from the VCU/BCM and user controls.

• **Washer Pump Motor:** Similar to the wiper motor, its activation is controlled by the system's logic based on user input.

**6. Instrument Cluster / Human-Machine Interface (HMI):**

• **Driver Feedback:** The instrument cluster displays information related to the wiper and washer system, such as:

• Wiper status (e.g., intermittent speed setting).

• Washer fluid low warning.

• Wiper system fault indicators.

• **User Input (Wiper/Washer Stalk):** While the stalk is the direct input device, its signals are processed by other systems before reaching the wiper/washer system.

**In summary, the Wiper and Washer System is not an isolated unit. It's an integrated part of the vehicle's electrical and electronic architecture, relying on:**

• **Power:** For basic operation.

• **Central Control Units (VCU/BCM):** For interpreting user inputs, managing vehicle states, and coordinating functions.

• **Communication Networks (CAN Bus):** For seamless data exchange.

• **Sensors:** For environmental awareness (rain) and system status (fluid level).

• **Driver Interface (Instrument Cluster):** For providing feedback and receiving initial commands.

3.5 Allocation and Distribution of Functions

*Clause: 5.4.2 e)*

Functions are distributed across systems in a complex and interconnected manner to optimize performance, efficiency, cost, and reliability. This distribution is driven by various factors, including the nature of the function itself, the capabilities of different hardware components, and the need for centralized control or distributed intelligence.

Here's a description of how functions are distributed, followed by a table illustrating common examples:

**Principles of Function Distribution:**

• **Centralized Control:** Some functions require a global view of the system or critical decision-making that is best handled by a central processing unit. This ensures consistency and allows for complex coordination.

• **Distributed Intelligence:** Other functions can be handled locally by dedicated hardware or software modules, reducing the load on the central processor and enabling faster, more responsive actions.

• **Hardware Acceleration:** Computationally intensive tasks are often offloaded to specialized hardware (e.g., GPUs, DSPs) for significant performance gains.

• **Resource Sharing:** Functions that have similar requirements or can benefit from shared resources (e.g., cooling, power) are often co-located or managed by a common system.

• **Modularity and Reusability:** Designing functions to be independent and reusable across different parts of a system or even different systems promotes flexibility and simplifies development.

• **Safety and Redundancy:** Critical safety functions might be duplicated or distributed across multiple systems to ensure operation even in case of failure.

• **Cost Optimization:** Distributing functions can help optimize hardware costs by using the most appropriate and cost-effective components for each task.

**Examples of Function Distribution:**

The following table illustrates common scenarios where functions are distributed across different systems. The "Primary System" is where the function is primarily managed or executed, while "Shared/Co-located Systems" indicate where the function might also reside, be influenced by, or contribute to.

| Function Category | Specific Function Example | Primary System | Shared/Co-located Systems

3.6 Operational Scenarios Impacting Functionality

*Clause: 5.4.2 f)*

Here are real-world scenarios affecting the Wiper and Washer System, categorized for clarity, and essential for realistic Hazard Analysis and Risk Assessment (HARA):

Real-World Scenarios Affecting Wiper and Washer System for HARA

These scenarios can impact the functionality, reliability, and safety of the wiper and washer system, leading to potential hazards.

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1. Environmental Conditions & Weather

• **Heavy Rain/Downpour:**

• **Effect:** Overwhelms wiper capacity, leading to reduced visibility. Washer fluid might be ineffective against heavy water accumulation.

• **HARA Relevance:** Reduced visibility can lead to collisions.

• **Snow/Blizzard:**

• **Effect:** Ice buildup on wipers, freezing of washer fluid, snow accumulation on the windshield obscuring vision. Wiper motor strain.

• **HARA Relevance:** Complete loss of visibility, potential for wiper damage, inability to clear the windshield.

• **Freezing Temperatures/Cold Start:**

• **Effect:** Washer fluid freezes in lines and nozzles, wiper blades freeze to the windshield, wiper motor struggles to move frozen blades.

• **HARA Relevance:** Inability to clear the windshield, potential for damage to the system, driver frustration leading to unsafe actions.

• **Fog/Mist:**

• **Effect:** Washer fluid might smear the fog, making visibility worse. Wipers might not be effective enough to clear the fine droplets.

• **HARA Relevance:** Gradual reduction in visibility, potential for driver over-reliance on a system that isn't fully effective.

• **Dust/Sand Storms:**

• **Effect:** Abrasive particles can damage wiper blades and windshield. Washer fluid might be insufficient to remove thick dust.

• **HARA Relevance:** Reduced visibility, potential for windshield damage, increased wear on wiper components.

• **Hail:**

• **Effect:** Can damage wiper blades, potentially crack the windshield.

• **HARA Relevance:** Damage to critical visibility components.

• **High Humidity/Condensation:**

• **Effect:** Internal condensation within the wiper motor or control module, potentially leading to electrical issues.

• **HARA Relevance:** Intermittent or complete system failure.

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2. Vehicle Operation & Dynamics

• **High Speed Driving:**

• **Effect:** Wind lift can reduce wiper effectiveness, especially at the edges of the windshield. Washer fluid spray pattern might be disrupted.

• **HARA Relevance:** Reduced visibility at speeds where reaction times are critical.

• **Sudden Braking/Acceleration:**

• **Effect:** Can cause temporary disruption to wiper operation if the system is not robustly designed.

• **HARA Relevance:** Momentary loss of visibility during critical maneuvers.

• **Off-Road Driving/Bumpy Terrain:**

• **Effect:** Vibrations can loosen connections, damage components, or cause intermittent operation.

• **HARA Relevance:** Unreliable system performance in challenging conditions.

• **Flooded Road/Deep Water Crossing:**

• **Effect:** Water ingress into the wiper motor housing or electrical connectors, leading to short circuits or corrosion.

• **HARA Relevance:** Complete system failure, potential for electrical fires.

• **Driving Through Mud/Slush:**

• **Effect:** Similar to dust/sand, can clog nozzles and damage blades.

• **HARA Relevance:** Reduced visibility, potential for system damage.

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3. Vehicle Systems & Maintenance

• **Fast Charging (EVs):**

• **Effect:** High electrical loads during fast charging could potentially interfere with or overload the wiper system's power supply if not properly managed. This is more of a concern for older or poorly designed systems.

• **HARA Relevance:** Potential for intermittent or complete system failure during a critical charging phase, especially if the driver needs to clear the windshield immediately after charging.

• **Low Washer Fluid Level:**

• **Effect:** Inability to clear the windshield effectively, especially when combined with dirt or debris.

• **HARA Relevance:** Reduced visibility, potential for driver frustration and unsafe attempts to clear the windshield.

• **Worn/Damaged Wiper Blades:**

• **Effect:** Streaking, chattering, and ineffective clearing of the windshield.

• **HARA Relevance:** Reduced visibility, driver distraction.

• **Clogged Washer Nozzles:**

• **Effect:** Inability to spray washer fluid onto the windshield, rendering the washer function useless.

• **HARA Relevance:** Inability to clear debris or improve visibility.

• **Electrical System Faults (e.g., blown fuse, faulty relay, wiring issues):**

• **Effect:** Complete or intermittent failure of the wiper and/or washer system.

• **HARA Relevance:** Loss of critical visibility clearing function.

• **Battery Drain/Low Battery Voltage:**

• **Effect:** Insufficient power to operate the wiper motor effectively, leading to slow or no operation.

• **HARA Relevance:** Reduced visibility, potential for system failure.

• **Software Glitches/ECU Malfunctions:**

• **Effect:** Unintended operation (e.g., wipers running continuously), failure to respond to commands, or incorrect speed selection.

• **HARA Relevance:** Distraction, unexpected behavior, potential for reduced visibility if wipers stop mid-sweep.

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4. External Events & Accidents

• **Collision (Minor or Major):**

• **Effect:** Physical damage to the wiper arms, blades, motor, or washer fluid reservoir/lines. Electrical system damage.

• **HARA Relevance:** Complete loss of function, potential for sharp or broken wiper components becoming projectiles.

• **Debris Impact (e.g., falling branches, rocks):**

• **Effect:** Damage to wiper blades, arms, or the windshield itself.

• **HARA Relevance:** Reduced visibility, potential for system damage.

• **Vandalism:**

• **Effect:** Deliberate damage to wiper arms, blades, or nozzles.

• **HARA Relevance:** Loss of function, potential for sharp edges.

• **Animal Strike:**

• **Effect:** Can cause physical damage to the wiper system or windshield.

• **HARA Relevance:** Reduced visibility, potential for system damage.

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5. Driver Interaction & Human Factors

• **Driver Distraction:**

• **Effect:** Driver may not notice the need for wipers or washers, or may not operate them correctly.

• **HARA Relevance:** Delayed or absent clearing of the windshield, leading to reduced visibility.

• **Driver Error (e.g., incorrect speed selection, attempting to use wipers on dry windshield):**

• **Effect:** Premature wear on wiper blades, potential for damage to the windshield or wiper mechanism.

• **HARA Relevance:** Reduced system lifespan, potential for damage that leads to future failure.

• **Driver Fatigue:**

• **Effect:** Similar to distraction, reduced awareness of environmental conditions and system needs.

• **HARA Relevance:** Delayed or absent clearing of the windshield.

• **Driver Attempting to Clear Obstructions Manually:**

• **Effect:** Risk of injury from sharp wiper components or broken glass.

• **HARA Relevance:** Direct driver injury.

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When conducting HARA, it's crucial to consider not just the direct failure of the wiper and washer system but also how these scenarios can *indirectly* impact driver behavior and overall vehicle safety by affecting visibility. Each scenario should be analyzed for its potential to cause a hazardous event and the severity of that event.

4. Conclusion

To confirm if your Item Definition satisfies ISO 26262-3:2018 Clause 5.4 and enables proceeding to HARA (Clause 6) and Safety Concept (Clause 7), and to summarize its coverage, I need to **see the actual Item Definition you are referring to.**

**Please provide your Item Definition.**

Once you provide it, I will analyze it against the requirements of ISO 26262-3:2018 Clause 5.4 and explain how it supports the subsequent phases.

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**In the meantime, here's a breakdown of what ISO 26262-3:2018 Clause 5.4 entails and what I will be looking for in your Item Definition:**

**ISO 26262-3:2018 Clause 5.4 - Item Definition**

This clause is crucial for establishing the foundation of the safety lifecycle. It requires a clear and comprehensive definition of the "Item" – the system or function that is the subject of the safety analysis. A well-defined Item Definition ensures that everyone involved understands what is being analyzed and what its boundaries are.

**Key elements typically required in an Item Definition according to Clause 5.4 include:**

1. **Item Name and Identification:** A clear and unique name for the item.

2. **Item Description:** A concise explanation of what the item is and what it does. This should include its primary functions and purpose.

3. **Item Boundaries:**

• **System Boundaries:** What is included within the item and what is considered external. This often involves defining hardware, software, and interfaces.

• **Functional Boundaries:** What specific functions are being considered for safety analysis.

4. **Item Context:**

• **Intended Use:** How the item is expected to be used in its operational environment.

• **Operational Environment:** The conditions under which the item will operate (e.g., temperature, vibration, electromagnetic compatibility).

• **Interaction with Other Items/Systems:** How the item interacts with other components or systems in the vehicle.

5. **Item Requirements (Initial):** High-level requirements that the item must fulfill, especially those related to its intended function and safety.

6. **Assumptions and Constraints:** Any assumptions made about the item's operation, the environment, or the capabilities of other systems, as well as any limitations or constraints.

7. **Scope of the Safety Analysis:** Clearly stating what aspects of the item are subject to the safety analysis.

**How a Satisfactory Item Definition Enables Proceeding to HARA (Clause 6) and Safety Concept (Clause 7):**

• **HARA (Hazard Analysis and Risk Assessment - Clause 6):**

• **Clear Scope:** The Item Definition provides the boundaries for identifying potential hazards. Without clear boundaries, it's impossible to systematically identify all relevant failure modes and their potential consequences.

• **Understanding Functionality:** A good description of the item's function allows for the identification of hazardous events that could arise from malfunctions or unintended behavior.

• **Contextualization:** The operational environment and interactions with other systems help in understanding how hazards might manifest and propagate.

• **Safety Concept (Clause 7):**

• **Basis for Safety Goals:** The HARA, informed by the Item Definition, leads to the definition of safety goals. The Item Definition ensures these goals are relevant to the item's intended function and its potential hazards.

• **Defining Safety Requirements:** The Safety Concept translates safety goals into concrete safety requirements. The Item Definition provides the necessary detail about the item's architecture and interfaces to derive these requirements effectively.

• **Allocation of Safety Functions:** The Item Definition helps in understanding where safety functions can be allocated within the item's architecture.

**Summary of Coverage I Will Be Looking For:**

Once you provide your Item Definition, I will summarize its coverage by assessing:

• **Completeness:** Does it address all the key elements of Clause 5.4?

• **Clarity and Unambiguity:** Is the definition easy to understand and free from misinterpretation?

• **Consistency:** Are the different parts of the definition consistent with each other?

• **Sufficiency for HARA:** Does it provide enough information to effectively perform a Hazard Analysis and Risk Assessment?

• **Sufficiency for Safety Concept:** Does it lay the groundwork for developing a robust Safety Concept?

• **Identification of Interfaces:** Are external interfaces clearly defined, as these are critical for HARA and Safety Concept development?

• **Identification of Operational Modes:** Are different operational modes of the item considered, as hazards can vary between modes?

**Please share your Item Definition so I can provide a specific confirmation and summary.**

5. Approvals

Here's a placeholder table for the roles you requested, ready to be filled in:

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**Approvals**

| Role | Name | Signature | Date |

|------------------|------|-----------|------|

| Safety Engineer | | | |

| System Architect | | | |

| Project Manager | | | |

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