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Test Plan for Lane Management Service with diagnostic report with Diagnostic error code analysis

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1. Introduction

1.1. Purpose

The purpose of this test plan is to outline the testing strategy for the Lane Management Service (LMS) integrated with a car, ensuring it meets the functional, integration, and performance requirements within the AUTOSAR (AUTomotive Open System ARchitecture) layered architecture.

1.2. Project Overview

The project involves integrating a Lane Management Service into a car's existing architecture. This includes lane departure warning, lane keeping assist, and related diagnostics, all implemented using the AUTOSAR layered architecture.

1.3. Audience

This document is intended for project managers, developers, testers, and stakeholders involved in the development and deployment of the Lane Management Service.

2. Test Strategy

2.1. Test Objectives

- Validate the functional requirements of the Lane Management Service.
- Ensure seamless integration with other vehicle systems.
- Test the system's performance under various conditions.
- Confirm the system's compliance with AUTOSAR standards.

2.2. Test Assumptions

- The hardware components are pre-tested and functioning correctly.
- The test environment mimics the real-world operating conditions of the car.
- Access to all necessary documentation and specifications.

2.3. Test Principles

- Adherence to AUTOSAR standards.
- Comprehensive coverage of all functional and non-functional requirements.
- Systematic and repeatable testing processes.

2.4. Data Approach

- Use of realistic data sets for lane management scenarios and diagnostics.
- Test data should cover a range of use cases, including edge cases.

2.5. Scope and Levels of Testing

2.5.1. Unit Testing
- Application Layer:
  - Verify individual functions of the lane management application.
  - Validate user interface responses to inputs.
- Runtime Environment (RTE):
  - Check RTE configuration and data exchange between application and BSW.
  - Validate task scheduling and timing requirements.
- Basic Software (BSW) Modules:
  - Test communication services (COM, PDU Router).
  - Validate memory services (NvM, MemStack).
  - Check diagnostic services (DEM, DCM).
- Microcontroller Abstraction Layer (MCAL):
  - Verify peripheral drivers (CAN, Ethernet).
  - Test microcontroller-specific configurations.

2.5.2. Integration Testing
- Communication Interfaces:
  - Validate CAN and Ethernet communication between lane management components.
  - Test data exchange between head unit and external devices (e.g., diagnostic tools).
- Sensor Integration:
  - Verify functionality of lane detection sensors and cameras.
  - Check integration with vehicle's braking and steering systems.
- User Interface Integration:
  - Verify display and alerts for lane departure and lane keeping assist.
  - Check responsiveness and accuracy of user controls.

2.5.3. System Testing
- System Boot and Shutdown:
  - Verify system start-up and shutdown sequences.
  - Check for error-free initialization and graceful shutdown.
- Functional Scenarios:
  - Test common use cases (e.g., lane departure warning, lane keeping assist).
  - Validate multi-functionality (simultaneous operation of multiple systems).
- Stress and Load Testing:
  - Assess system performance under high load conditions.
  - Validate system behavior under extended operation.
- Failover and Recovery:
  - Test system response to component failures.
  - Validate recovery mechanisms and data integrity.

2.5.4. User Acceptance Testing (UAT)
- Conduct UAT with real users to ensure the system meets their needs and expectations.
- Collect feedback and make necessary adjustments.

2.5.5. Performance Testing
- Measure response times for user inputs and system commands.
- Assess data transfer rates and communication latency.
- Monitor CPU, memory, and network usage.
- Validate system performance under varying resource availability.

2.5.6. Security Testing
- Ensure the lane management system is secure from external threats.
- Test for vulnerabilities and potential breaches.

2.5.7. Regression Testing
- Re-run previous test cases to ensure new updates do not break existing functionalities.
- Validate bug fixes and new features.

2.6. Test Effort Estimate
- Exploratory Testing: 5 days
- Functional Testing: 15 days
- Integration Testing: 10 days
- System Testing: 12 days
- UAT: 8 days
- Performance Testing: 5 days
- Security Testing: 5 days
- Regression Testing: 8 days

3. Test Acceptance Criteria

- All high and medium severity defects are resolved.
- Functional test cases achieve a pass rate of 95%.
- Integration and system test cases achieve a pass rate of 98%.
- Performance benchmarks for response time, lane detection accuracy, and user interface responsiveness are met.
- Security tests show no vulnerabilities.

4. Test Deliverables

- Test Plan Document
- Test Cases and Test Scripts
- Test Execution Reports
- Defect Logs and Resolution Reports
- UAT Feedback Reports
- Final Test Summary Report

5. Risk Management

- Identify Potential Risks: Hardware failures, software bugs, communication breakdowns.

- Mitigation Strategies:

  - Implement robust error-handling and recovery mechanisms.

  - Conduct thorough pre-testing of individual components.

  - Regularly update and review test plans based on feedback and findings.

  - Allocate additional time for unforeseen issues during test phases.

6. AUTOSAR Layered Architecture Explanation

AUTOSAR (AUTomotive Open System ARchitecture) is a standardized automotive software architecture that provides a framework for developing and integrating complex automotive software systems. It divides the software into several layers to simplify development, enhance modularity, and ensure interoperability.

Application Layer:
- Contains the functional software components that implement specific application functionalities, such as lane management.

Runtime Environment (RTE):
- Acts as a middleware layer, providing communication services between software components and between software components and the Basic Software (BSW) layer.

Basic Software (BSW):
- Includes standardized software modules that provide services for communication, memory management, diagnostic services, and operating system functionality.

Microcontroller Abstraction Layer (MCAL):
- Provides a hardware abstraction layer that allows the higher layers to be hardware-independent. It includes drivers for peripherals like CAN, Ethernet, and other communication interfaces.

7. BOD, UDS, and DoIP Explanation

BOD (Base Operating Diagnostic):
- A foundational diagnostic service that provides basic diagnostic functionalities, such as error code reading and clearing, and basic system health checks.

UDS (Unified Diagnostic Services):
- A set of standard diagnostic services defined in ISO 14229. UDS provides a comprehensive set of diagnostic and communication services, including fault code management, data streaming, and system reset functions.

DoIP (Diagnostics over Internet Protocol):
- A diagnostic protocol defined in ISO 13400 that allows diagnostic communication over IP networks. DoIP facilitates remote diagnostics and software updates by leveraging standard IP networking technologies.

8. Diagnostics of the Defects

User Interface Diagnostics:
- Error Display:
  - Check the diagnostic information displayed on the user interface for clarity and accuracy.
  - Ensure that users are informed of system errors and their severity.
- Troubleshooting Guidance:
  - Validate that the user interface provides troubleshooting steps or suggestions for resolving errors.
  - Ensure the diagnostic interface is user-friendly and accessible.

Diagnostic Logging and Reporting:
- Log Generation:
  - Ensure the system generates detailed diagnostic logs for all detected errors and anomalies.
  - Validate the accuracy and completeness of diagnostic logs.
- Reporting:
  - Test the system's ability to compile and report diagnostic information to external systems or maintenance personnel.
  - Verify that the reporting format is consistent with industry standards.

Periodic Self-Checks:
- Automated Diagnostics:
  - Validate the system's ability to perform periodic self-checks and diagnostics.
  - Ensure that these self-checks cover all critical components and functions of the lane management system.
- Alert Generation:
  - Test the system's ability to generate alerts for any issues detected during self-checks.
  - Ensure timely notification of potential problems to the user or maintenance system.

Making Diagnostics Easier with AUTOSAR:
- Standardized Interfaces:
  - AUTOSAR provides standardized diagnostic interfaces and services, which simplifies the integration and interoperability of diagnostic tools.
- Modularity:
  - The layered architecture allows for modular diagnostics, making it easier to isolate and diagnose specific components or functions.
- Scalability:
  - AUTOSAR's scalable framework supports a wide range of diagnostic capabilities, from basic error reporting to advanced remote diagnostics.

9. Diagnostic Error Code Analysis

Error Code Structure:
- Diagnostic trouble codes (DTCs) are structured codes that identify specific issues within the lane management system. These codes follow a standardized format, making it easy to interpret and address errors.

Common DTCs for Lane Management:
- U0010: Communication error between the lane management module and the central control unit.
- C1100: Lane detection sensor malfunction.
- B1240: User interface display error.
- P2560: Lane keeping assist system failure.

Analysis Process:
- Detection:
  - The system continuously monitors for faults and logs DTCs when issues are detected.
- Logging:
  - DTCs are stored in the system's memory and can be accessed through diagnostic tools.
- Reporting:
  - Diagnostic reports compile these DTCs and provide detailed information about the nature and severity of the issues.
- Resolution:
  - Maintenance personnel use the diagnostic reports to identify and resolve issues, ensuring the lane management system operates correctly.

Example:
- If the lane management system detects a malfunction in the lane detection sensor, it logs a DTC such as C1100. This code is then displayed on the user interface, along with troubleshooting steps to resolve the issue. The diagnostic log is generated and can be reviewed by maintenance personnel, who can use the standardized DTC format to quickly understand and fix the problem.

10.Diagnostic Error Codes for Cruise Control System

A. Unit Test Cases

1. Application Layer
   - Set Speed Function:
   - Test Case: Verify that the set speed function correctly maintains the desired speed.
   - Expected Result: The vehicle maintains the set speed accurately without fluctuations.
   - Potential Defect: The vehicle speed fluctuates instead of maintaining a constant speed.
   - Error Code: P0500 (Vehicle Speed Sensor Malfunction).

2. Runtime Environment (RTE):
   - Service Call Execution:
   - Test Case: Validate that service calls from the Cruise Control application to other software components execute correctly.
   - Expected Result: All service calls execute without errors and within the required time frame.
   - Potential Defect: Service call delays leading to delayed throttle response.
   - Error Code: N/A (Performance issue without specific DTC).

3. Basic Software (BSW) Modules:
   - Communication Service Validation:
   - Test Case: Test the data exchange between the Cruise Control system and other ECUs via the CAN network.
   - Expected Result: Data packets are transmitted and received correctly without loss.
   - Potential Defect: Data packets are lost or corrupted during transmission.
   - Error Code: U0100 (Lost Communication with ECM/PCM).

B. Integration Test Cases

1. User Interface Integration:
   - Touchscreen Functionality:
   - Test Case: Verify the touchscreen interface responds correctly to inputs for setting and adjusting the cruise control speed.
   - Expected Result: The touchscreen responds accurately and swiftly to all inputs.
   - Potential Defect: Touchscreen unresponsive or inputs are not correctly processed.
   - Error Code: B1503 (Touch Screen Circuit Malfunction).

2. Sensor Integration:
   - Brake Switch Input:
   - Test Case: Test the system's response to brake switch input by pressing the brake pedal while cruise control is active.
   - Expected Result: Cruise Control disengages immediately upon brake application.
   - Potential Defect: Cruise Control does not disengage or delays in disengaging.
   - Error Code: P0571 (Brake Switch "A" Circuit Malfunction).

C. System Test Cases

1. System Boot and Shutdown:
   - Startup Sequence:
     - Test Case: Verify that the Cruise Control system initializes correctly during vehicle startup.
     - Expected Result: The system initializes without errors and is ready for use.
     - Potential Defect: System fails to initialize or shows error messages.
     - Error Code: P0650 (Malfunction Indicator Lamp (MIL) Control Circuit).

2. Functional Scenarios:
   - Maintaining Speed Uphill:
     - Test Case: Test the vehicle's ability to maintain the set speed while driving uphill.
     - Expected Result: The vehicle maintains the set speed with appropriate throttle adjustments.
     - Potential Defect: Vehicle slows down or speeds up unexpectedly.
     - Error Code: P0500 (Vehicle Speed Sensor Malfunction).

D. Regression Test Cases

1. Re-run Previous Test Cases:
   - Existing Feature Validation:
     - Test Case: Re-run all previous test cases to ensure no existing functionalities are broken by new updates.
     - Expected Result: All previously passed test cases should pass again.
     - Potential Defect: Previously fixed issues reappear.
     - Error Code: Varies based on specific defect reoccurrence.

E. Performance Test Cases

1. Latency and Throughput:
   - Response Time:
     - Test Case: Measure the response time for the system to engage or disengage Cruise Control.
     - Expected Result: The system should engage or disengage within the specified time limits.
     - Potential Defect: Delayed engagement or disengagement.
     - Error Code: N/A (Performance issue without specific DTC).

F. Compliance Test Cases

1. AUTOSAR Standards:
   - Module Configuration:
     - Test Case: Validate that all software components conform to AUTOSAR standards.
     - Expected Result: All components are compliant and properly configured.
     - Potential Defect: Non-compliance with AUTOSAR standards.
     - Error Code: N/A (Compliance issue without specific DTC).

Potential Defects and Error Codes

- **P0500**: Vehicle Speed Sensor Malfunction
  - Description: This code indicates a malfunction in the vehicle speed sensor, which can affect the ability to maintain the set speed.

- **P0564**: Cruise Control Multi-Function Input "A" Circuit
  - Description: This code indicates an issue with the multi-function input circuit for cruise control, affecting input recognition.

- **P0571**: Brake Switch "A" Circuit Malfunction
  - Description: This code points to a malfunction in the brake switch circuit, which is crucial for disengaging the cruise control.

- **P0581**: Cruise Control Multi-Function Input "A" Circuit High
  - Description: This code indicates a high voltage issue in the multi-function input circuit for cruise control, affecting control inputs.

- **U0100**: Lost Communication with ECM/PCM
  -Description: This code signifies a loss of communication with the engine control module or powertrain control module, which can disrupt cruise control operation.

- **B1503** Touch Screen Circuit Malfunction
  -Description: This code indicates a malfunction in the touch screen circuit, affecting user interface functionality.

- **P0650**: Malfunction Indicator Lamp (MIL) Control Circuit
  -Description: This code points to an issue with the MIL control circuit, which can indicate broader system failures.

11. QA Perspective on Handling DTCs

1. Detection and Logging:
   - Ensure accurate fault detection and logging.

2. Validation:
   - Validate DTC accuracy and consistency through testing.

3. Reporting:
   - Ensure clear, standardized diagnostic reports.

4. User Interface Testing:
   - Test UI for accurate error display and user-friendly troubleshooting.

5. Resolution Process:
   - Confirm easy access and interpretation of DTCs by maintenance staff.

6. Continuous Improvement:
   - Use feedback to refine diagnostic systems and enhance reliability.

12. Monitor, Controller and Actuator

Monitor:

Cameras:
- Forward-facing Cameras: Continuously capture images of the road ahead to detect lane markings.
- Side Cameras: Monitor the vehicle's position within the lane and adjacent lanes.
- LIDAR/RADAR Sensors:
- LIDAR: Provides high-resolution, 3D mapping of the vehicle's surroundings, including lane markings, road edges, and obstacles.

RADAR:
- Measures distances to objects and vehicles to ensure the lane is clear.
- Inertial Measurement Unit (IMU):
- Measures vehicle dynamics, including yaw rate, acceleration, and angular velocity.

GPS:
- Provides precise vehicle location data to support lane recognition and map alignment.

Controller:

Lane-Keeping Algorithm:
- Uses image processing techniques (e.g., edge detection, Hough transform) to identify lane markings from camera data.

- Analyzes LIDAR/RADAR data to confirm the presence and position of lane boundaries.
- Combines sensor data with vehicle dynamics from the IMU to predict potential lane departures.

Decision-Making Unit:
- Determines the necessary steering corrections or warnings based on processed sensor data.
- Balances corrective actions with driver inputs and vehicle stability requirements.
- Incorporates map data and GPS information to enhance accuracy and predict upcoming lane changes.

Actuator:

Electric Power Steering (EPS) System:
- Executes steering adjustments to keep the vehicle centered in the lane.
- Can provide varying levels of intervention, from gentle nudges to stronger corrections.

Driver Alert System:
- Provides haptic feedback (e.g., vibrations in the steering wheel) to alert the driver.
- Visual and auditory warnings through the dashboard display and speakers to alert the driver of lane departure risks.

Brake and Throttle Integration (if equipped with autonomous lane correction):
- Applies light braking or throttle adjustments to assist in smooth lane keeping

THANK YOU