# Functional Requirement

1. Functional Requirements  
  
1.1 Data Processing and Analysis Function   
Function ID: FR-01   
Description: The system must process and analyze incoming Vehicle Infrastructure Integration (VII) data from various sources such as Probe Vehicles, Traffic Management Systems, Weather Stations, and Traveler Information Systems to generate actionable insights. This includes calculating traffic metrics, inferring incidents, and processing weather and road surface conditions.   
Input: Real-time data streams from Probe Vehicles, Traffic Management Systems, Weather Stations, and Traveler Information Systems.   
Output: Updated Traffic Metrics, Incident Details, Road Surface Conditions, and Weather Observations available for further use, alerts, and visualization.  
  
1.2 Traffic Data Collection Function   
Function ID: FR-02   
Description: The system must collect real-time traffic data from Probe Vehicles and other data sources. The data must be validated and integrated into the system for further analysis and dissemination.   
Input: Real-time data from Probe Vehicles including vehicle location, speed, and travel time.   
Output: Validated Traffic Data stored in the Oracle 10g database and updated in Traveler Information Systems.  
  
1.3 Traffic Metrics Analysis Function   
Function ID: FR-03   
Description: The system must analyze Traffic Data, Weather Data, and Road Condition Data to identify traffic patterns, congestion levels, travel times, and queue lengths. Analysis results must be formatted and disseminated to Traveler Information Systems.   
Input: Traffic Data, Weather Data, and Road Condition Data from the Oracle 10g database.   
Output: Analyzed Traffic Metrics, including congestion levels, travel times, and queue lengths, formatted for dissemination and stored in the Oracle 10g database.  
  
1.4 Traffic Incident Inference Function   
Function ID: FR-04   
Description: The system must detect and infer potential traffic incidents based on anomalies in traffic flow, such as sudden slowdowns or stops. Incident details must be extracted, classified, and disseminated to Traveler Information Systems and Traffic Management Systems.   
Input: Traffic Data, Weather Data, and Road Condition Data from Probe Vehicles, Traffic Management Systems, and Weather Stations.   
Output: Incident Details including location, severity, and description stored in the Oracle 10g database and published to Traveler Information Systems.  
  
1.5 Road Surface Condition Calculation Function   
Function ID: FR-05   
Description: The system must calculate road surface conditions based on data from Road Sensors, Weather Stations, and Probe Vehicles. The results must be integrated with Incident Details and Traffic Metrics to assess impacts on traffic flow.   
Input: Real-time data from Road Sensors, Weather Stations, and Probe Vehicles.   
Output: Calculated Road Surface Conditions stored in the Oracle 10g database and published to Traveler Information Systems.  
  
1.6 Weather Observation Processing Function   
Function ID: FR-06   
Description: The system must process real-time weather data from Weather Stations, including temperature, precipitation, and visibility. The data must be combined with Traffic Data and Road Condition Data to assess the impact on road safety and traffic flow.   
Input: Real-time Weather Data from Weather Stations.   
Output: Processed Weather Observations stored in the Oracle 10g database and integrated into traffic analysis and alert generation.  
  
1.7 Travel Demand Monitoring Function   
Function ID: FR-07   
Description: The system must monitor travel demand by analyzing data from Probe Vehicles, including origin, destination, and travel time. The results must be visualized on Map Displays and used to adjust traffic management strategies.   
Input: Travel Demand Data from Probe Vehicles and other data sources.   
Output: Travel Demand patterns stored in the Oracle 10g database and visualized on Map Displays.  
  
1.8 Data Quality Check Function   
Function ID: FR-08   
Description: The system must perform automated validation checks on incoming data to ensure accuracy, consistency, and completeness. Invalid or incomplete data must be logged and flagged for revalidation.   
Input: Traffic Data, Weather Data, Road Condition Data, and Incident Data from various sources.   
Output: Validated data passed to the next processing steps, or flagged data stored for revalidation.  
  
1.9 Dynamic Data Caching Function   
Function ID: FR-09   
Description: The system must implement dynamic data caching to temporarily store real-time data during high load or database unavailability. Cached data must be synchronized with the Oracle 10g database when the connection is restored.   
Input: Real-time data from Probe Vehicles, Traffic Management Systems, and Weather Stations.   
Output: Cached data stored in memory or local storage and synchronized with the Oracle 10g database.  
  
1.10 Long-Term Data Archiving Function   
Function ID: FR-10   
Description: The system must archive processed data, including Traffic Metrics, Road Condition Data, Incident Details, and Weather Observations, into the Oracle 10g database for long-term reference and historical analysis.   
Input: Processed data from DUAP, including Traffic Data, Weather Data, and Incident Data.   
Output: Archived data stored in the Oracle 10g database with structured indexing.  
  
1.11 Data Formatting for SAE J2354 Function   
Function ID: FR-11   
Description: The system must format processed data according to SAE J2354 standards for external system integration. The formatted data must be validated against the SAE J2354 schema.   
Input: Traffic Data, Weather Data, and Road Condition Data processed by the DUAP system.   
Output: SAE J2354-formatted data stored in the Oracle 10g database and ready for external system use.  
  
1.12 Data Formatting for TMDD Function   
Function ID: FR-12   
Description: The system must format processed data according to TMDD standards for integration with external traffic management systems. The data must be validated against the TMDD schema.   
Input: Traffic Data, Weather Data, and Road Condition Data processed by the DUAP system.   
Output: TMDD-formatted data stored in the Oracle 10g database and ready for external system use.  
  
1.13 Traffic Alert Publishing Function   
Function ID: FR-13   
Description: The system must publish traffic alerts based on analyzed data such as congestion levels, incidents, and road surface conditions. Alerts must be displayed on Web-Based User Interfaces and disseminated to Traveler Information Systems.   
Input: Incident Details, Traffic Metrics, and Road Surface Conditions from the DUAP system.   
Output: Traffic Alerts published to Web-Based User Interfaces and Traveler Information Systems and stored in the Oracle 10g database.  
  
1.14 Weather Alert Publishing Function   
Function ID: FR-14   
Description: The system must publish weather alerts based on hazardous weather conditions identified during processing. These alerts must be displayed on Web-Based User Interfaces and disseminated to Traveler Information Systems.   
Input: Weather Data and Road Condition Data processed by the DUAP system.   
Output: Weather Alerts published to Web-Based User Interfaces and Traveler Information Systems and stored in the Oracle 10g database.  
  
1.15 Asset Condition Alert Publishing Function   
Function ID: FR-15   
Description: The system must publish asset condition alerts, such as infrastructure failures or sensor malfunctions, to Web-Based User Interfaces and Traffic Management Systems. These alerts must be stored in the Oracle 10g database for historical tracking.   
Input: Asset Condition Data and Road Condition Data from the DUAP system.   
Output: Asset Condition Alerts published to Web-Based User Interfaces and Traffic Management Systems and stored in the Oracle 10g database.  
  
1.16 MI Drive Presentation Support Function   
Function ID: FR-16   
Description: The system must support the generation of MI Drive presentations by compiling real-time and historical data into a structured format. The presentation must include maps, icons, and textual summaries.   
Input: Traffic Data, Weather Data, and Road Condition Data processed and stored in the Oracle 10g database.   
Output: MI Drive Presentation data displayed on Map Displays and Icon Layers and stored in the Oracle 10g database.  
  
1.17 Traffic Information Browsing Function   
Function ID: FR-17   
Description: The system must allow the Administrator to browse real-time and historical traffic information, including congestion levels, travel times, and incident details, through Web-Based User Interfaces and Map Displays.   
Input: Traffic Data, Traffic Metrics, and Incident Details from the Oracle 10g database.   
Output: Traffic Information displayed on the Web-Based User Interface with filtering and visualization capabilities.  
  
1.18 Incident Information Browsing Function   
Function ID: FR-18   
Description: The system must allow the Administrator to browse incident data, including location, severity, and cause, through Web-Based User Interfaces and Map Displays.   
Input: Incident Details and Road Surface Conditions from the Oracle 10g database.   
Output: Incident Information displayed on the Web-Based User Interface with filtering and visualization capabilities.  
  
1.19 Traveler Information Browsing Function   
Function ID: FR-19   
Description: The system must allow the Administrator to browse traveler information, such as travel demand, traffic conditions, and weather alerts, through Web-Based User Interfaces and Map Displays.   
Input: Travel Demand Data, Traffic Data, and Weather Data from the Oracle 10g database.   
Output: Traveler Information displayed on the Web-Based User Interface with filtering and visualization capabilities.  
  
1.20 Asset Condition Information Browsing Function   
Function ID: FR-20   
Description: The system must allow the Administrator to browse asset condition data, including infrastructure status and sensor health, through Web-Based User Interfaces and Map Displays.   
Input: Asset Condition Data and Road Condition Data from the Oracle 10g database.   
Output: Asset Condition Information displayed on the Web-Based User Interface with filtering and visualization capabilities.  
  
1.21 Weather Information Browsing Function   
Function ID: FR-21   
Description: The system must allow the Administrator to browse weather-related data, including temperature, precipitation, and visibility, through Web-Based User Interfaces and Map Displays.   
Input: Weather Data and Weather Observations from the Oracle 10g database.   
Output: Weather Information displayed on the Web-Based User Interface with filtering and visualization capabilities.  
  
1.22 Map Display Function   
Function ID: FR-22   
Description: The system must display real-time and historical data in an interactive map format, including traffic, weather, and road condition data. Map layers must be configurable and support zooming and panning.   
Input: Traffic Data, Weather Data, Road Condition Data, and Incident Data from the Oracle 10g database.   
Output: Map Displays with real-time and historical data overlays and interactive capabilities.  
  
1.23 Icon Layer Management Function   
Function ID: FR-23   
Description: The system must allow the Administrator to manage icon layers on the map, including adjusting visibility, priority, and styling. Icon layers must be updated in real-time to reflect current data states.   
Input: Icon Layer configurations from the Oracle 10g database and real-time data from Probe Vehicles and Weather Stations.   
Output: Updated Icon Layers on the Map Displays with customized settings and real-time data reflection.  
  
1.24 De-Cluttering Capability Function   
Function ID: FR-24   
Description: The system must provide de-cluttering capabilities to improve map readability by reducing icon density in congested areas. De-cluttering settings must be configurable and saved for future use.   
Input: Map Display configurations and real-time data from Probe Vehicles and Weather Stations.   
Output: De-cluttered Map Displays with reduced icon density and real-time updates.  
  
1.25 Data Source Addition Function   
Function ID: FR-25   
Description: The system must allow the Administrator to add new data sources, such as Probe Vehicles, Weather Stations, or Road Sensors, and validate their data formats against predefined standards.   
Input: Details of the new data source, including type, location, and format.   
Output: New data source integrated into the system and stored in the Oracle 10g database.  
  
1.26 Algorithm Update Function   
Function ID: FR-26   
Description: The system must allow the Administrator to update or replace existing algorithms used for data processing and incident inference. Updated algorithms must be tested and activated in the processing pipeline.   
Input: New algorithm versions or custom algorithms provided by the Administrator.   
Output: Updated algorithm deployed in the DUAP system and stored in the Oracle 10g database.  
  
1.27 Output Format Modification Function   
Function ID: FR-27   
Description: The system must allow the Administrator to modify the output formats for data dissemination, such as changing from XML to JSON. The new format must be validated and applied to relevant modules.   
Input: New output format definitions for specific data types.   
Output: Modified output format applied to data streams and stored in the Oracle 10g database.  
  
1.28 Presentation Method Adjustment Function   
Function ID: FR-28   
Description: The system must allow the Administrator to adjust presentation methods for data visualization, including map themes, icon styles, and layer visibility. Adjustments must be applied in real-time to the Web-Based User Interfaces.   
Input: New presentation settings provided by the Administrator.   
Output: Updated presentation method applied to Map Displays and Icon Layers, stored in the Oracle 10g database.  
  
1.29 MDIT Standards Compliance Function   
Function ID: FR-29   
Description: The system must ensure all data processing, formatting, and dissemination functions comply with Michigan Department of Information Technology (MDIT) standards. Compliance checks must be logged for audit purposes.   
Input: Data entities processed by the DUAP system and compliance rules from MDIT standards.   
Output: Data formatted and structured to meet MDIT standards, stored in the Oracle 10g database and available for export.  
  
1.30 Java Software Foundation Integration Function   
Function ID: FR-30   
Description: The system must be built and run using the Java Software Foundation (JSF) to support a responsive and interactive Web-Based User Interface. JSF components must be used for dynamic data rendering and user interaction.   
Input: User interactions and data from Probe Vehicles, Weather Stations, and Traffic Management Systems.   
Output: Web-Based User Interface with dynamic components and real-time data updates.  
  
1.31 JDBC Database Connection Function   
Function ID: FR-31   
Description: The system must establish and maintain a JDBC connection to the Oracle 10g database to retrieve and store data entities. Connection details must be configurable and monitored for performance.   
Input: JDBC connection parameters provided by the Administrator.   
Output: Active JDBC connection to the Oracle 10g database with status and logs updated in the Web-Based User Interface.  
  
1.32 Oracle 10G Database Use Function   
Function ID: FR-32   
Description: The system must use the Oracle 10g database for long-term storage and retrieval of data entities, including Traffic Data, Weather Data, Incident Data, and Travel Demand Data.   
Input: Data entities to be stored or retrieved from the Oracle 10g database.   
Output: Data stored or retrieved from the Oracle 10g database, with logs and status updated for audit and troubleshooting.  
  
1.33 Standard SQL Query Execution Function   
Function ID: FR-33   
Description: The system must execute standard SQL queries on the Oracle 10g database to retrieve or modify data for analysis, reporting, or visualization. Query results must be formatted and displayed for the Administrator.   
Input: Standard SQL queries composed or selected by the Administrator.   
Output: Query results displayed on the Web-Based User Interface and stored in the Oracle 10g database.  
  
1.34 Michigan Geographic Framework Application Function   
Function ID: FR-34   
Description: The system must apply the Michigan Geographic Framework (MIGF) to align data with geographic coordinates and road networks for accurate spatial visualization.   
Input: Traffic Data, Weather Data, and Road Condition Data from the DUAP system.   
Output: Data aligned with MIGF and displayed on Map Displays for spatial analysis.  
  
1.35 User Role Management Function   
Function ID: FR-35   
Description: The system must allow the Administrator to manage user roles and permissions, ensuring that only authorized users can perform specific actions. Role changes must be logged for audit purposes.   
Input: User and role details provided by the Administrator.   
Output: Updated user role assignments stored in the Oracle 10g database and applied to the system components.  
  
1.36 System Security Maintenance Function   
Function ID: FR-36   
Description: The system must maintain system security by enforcing access controls, monitoring for unauthorized access attempts, and logging security-related activities for audit and compliance.   
Input: Security policies and user access requests.   
Output: Enforced security settings, logged access attempts, and real-time security alerts.  
  
1.37 System Performance Monitoring Function   
Function ID: FR-37   
Description: The system must monitor real-time system performance, including CPU usage, memory utilization, and database response time. Performance metrics must be displayed and logged for troubleshooting.   
Input: Performance data from system components and the Oracle 10g database.   
Output: Performance metrics visualized on the Web-Based User Interface and stored in the Oracle 10g database.  
  
1.38 Traffic Report Generation Function   
Function ID: FR-38   
Description: The system must generate traffic reports based on processed Traffic Data, Incident Data, and Weather Data. Reports must include visual and textual summaries and be exportable in standard formats.   
Input: Traffic Data, Incident Data, and Weather Data from the Oracle 10g database.   
Output: Traffic Report displayed on the Web-Based User Interface and stored in the Oracle 10g database.  
  
1.39 Weather Report Generation Function   
Function ID: FR-39   
Description: The system must generate weather reports based on processed Weather Data and Road Condition Data. Reports must include weather observations, road surface conditions, and traffic impact summaries.   
Input: Weather Data and Road Condition Data from the Oracle 10g database.   
Output: Weather Report displayed on the Web-Based User Interface and stored in the Oracle 10g database.  
  
1.40 Road Condition Report Generation Function   
Function ID: FR-40   
Description: The system must generate road condition reports based on processed Road Surface Conditions, Weather Observations, and Incident Details. Reports must be exportable and displayed for situational awareness.   
Input: Road Surface Conditions, Weather Observations, and Incident Details from the Oracle 10g database.   
Output: Road Condition Report displayed on the Web-Based User Interface and stored in the Oracle 10g database.  
  
1.41 Data Integrity Maintenance Function   
Function ID: FR-41   
Description: The system must maintain data integrity through continuous validation and consistency checks. Invalid or inconsistent data must be flagged and logged for revalidation.   
Input: Traffic Data, Weather Data, Road Condition Data, and Incident Data from data sources.   
Output: Validated data passed to processing modules or flagged for revalidation and stored in the Oracle 10g database.  
  
1.42 Data Source Status Tracking Function   
Function ID: FR-42   
Description: The system must track the status of all data sources, including Probe Vehicles, Weather Stations, and Road Sensors, to ensure they are transmitting data correctly. Status logs must be displayed for the Administrator.   
Input: Status data from Probe Vehicles, Weather Stations, and Road Sensors.   
Output: Data Source Status Dashboard displayed on the Web-Based User Interface and stored in the Oracle 10g database.  
  
1.43 Incident Detail Update Function   
Function ID: FR-43   
Description: The system must allow the Administrator to update Incident Details, such as severity or location, and synchronize the changes with the DUAP system and Traveler Information Systems.   
Input: Incident Details provided by the Administrator for modification.   
Output: Updated Incident Details stored in the Oracle 10g database and reflected in Web-Based User Interfaces.  
  
1.44 Outdated Data Deletion Function   
Function ID: FR-44   
Description: The system must allow the Administrator to delete outdated data from the Oracle 10g database based on a predefined data retention policy. Deletion logs must be recorded for audit.   
Input: Data retention policy and data to be deleted.   
Output: Outdated Data deleted from the Oracle 10g database with logs stored for audit.  
  
1.45 Traveler Information Modification Function   
Function ID: FR-45   
Description: The system must allow the Administrator to modify traveler information such as alerts, detour suggestions, and advisories. The changes must be disseminated to Traveler Information Systems and visualized on Map Displays.   
Input: Modified traveler information provided by the Administrator.   
Output: Updated Traveler Information stored in the Oracle 10g database and disseminated to connected systems.  
  
1.46 System Configuration Management Function   
Function ID: FR-46   
Description: The system must allow the Administrator to modify system configurations, including data thresholds, caching policies, and alert rules. Configuration changes must be applied and stored for future use.   
Input: System configuration parameters provided by the Administrator.   
Output: Updated system configuration stored in the Oracle 10g database and applied to the DUAP system.  
  
1.47 Historical Traffic Data Retrieval Function   
Function ID: FR-47   
Description: The system must allow the Administrator to retrieve historical traffic data for analysis, including congestion levels, travel times, and incident details.   
Input: Date range, location, and data type specified by the Administrator.   
Output: Historical Traffic Data displayed on the Web-Based User Interface and synchronized with Map Displays.  
  
1.48 Historical Weather Data Retrieval Function   
Function ID: FR-48   
Description: The system must allow the Administrator to retrieve historical weather data for analysis, including temperature, precipitation, and visibility.   
Input: Date range, location, and weather data type specified by the Administrator.   
Output: Historical Weather Data displayed on the Web-Based User Interface and synchronized with Map Displays.  
  
1.49 Historical Road Condition Data Retrieval Function   
Function ID: FR-49   
Description: The system must allow the Administrator to retrieve historical road condition data for analysis, including road surface conditions and incident details.   
Input: Date range, location, and data type specified by the Administrator.   
Output: Historical Road Condition Data displayed on the Web-Based User Interface and synchronized with Map Displays.  
  
1.50 DataRecord Management Function   
Function ID: FR-50   
Description: The system must allow the Administrator to manage DataRecords, including viewing, editing, deleting, and archiving. Changes must be synchronized with the Oracle 10g database.   
Input: DataRecord details provided by the Administrator for management.   
Output: Modified or archived DataRecords stored in the Oracle 10g database and reflected in the Web-Based User Interface.  
  
1.51 System Log Management Function   
Function ID: FR-51   
Description: The system must allow the Administrator to view, filter, search, export, and delete system logs for auditing, troubleshooting, or analysis.   
Input: Log queries and actions provided by the Administrator.   
Output: System Logs displayed and managed on the Web-Based User Interface and stored in the Oracle 10g database.  
  
1.52 UserSession Management Function   
Function ID: FR-52   
Description: The system must allow the Administrator to manage user sessions, including terminating, extending, or reviewing session logs. Session data must be stored in the Oracle 10g database.   
Input: Session management actions provided by the Administrator.   
Output: Updated UserSession status stored in the Oracle 10g database and displayed on the Web-Based User Interface.  
  
1.53 AlertConfiguration Management Function   
Function ID: FR-53   
Description: The system must allow the Administrator to configure, modify, or delete alert rules and thresholds. Changes must be applied to the DUAP system for real-time alerting.   
Input: Alert configuration parameters provided by the Administrator.   
Output: Updated AlertConfiguration stored in the Oracle 10g database and applied to alert generation logic.  
  
1.54 CacheEntry Management Function   
Function ID: FR-54   
Description: The system must allow the Administrator to manage cache entries, including viewing, modifying expiration policies, and manually deleting entries. Cache data must be synchronized with the Oracle 10g database when available.   
Input: CacheEntry management actions provided by the Administrator.   
Output: Updated CacheEntry status stored in the Oracle 10g database and reflected in the Web-Based User Interface.  
  
1.55 ArchiveEntry Management Function   
Function ID: FR-55   
Description: The system must allow the Administrator to manage archive entries, including viewing, editing, deleting, or restoring archived data. Archive changes must be logged for audit purposes.   
Input: ArchiveEntry management actions provided by the Administrator.   
Output: Updated ArchiveEntry status stored in the Oracle 10g database and displayed on the Web-Based User Interface.

# External Description

\*\*Chapter 2: External Interfaces\*\*  
  
This chapter defines the external interfaces that the system must interact with to fulfill its functional requirements. These interfaces include user interfaces, hardware interfaces, software interfaces, and communication interfaces. Each interface is described in terms of its role, format, and method of interaction with the system.  
  
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### \*\*2.1 User Interfaces\*\*  
  
The system provides a \*\*Web-Based User Interface (WUI)\*\* to support real-time and historical data visualization, administration, and configuration.  
  
- \*\*Description\*\*:   
 The Web-Based User Interface is the primary interface for the system Administrator and operators to interact with the system. It supports dynamic rendering of data, configuration settings, and real-time monitoring of system performance and data flows.  
  
- \*\*Role\*\*:   
 Facilitates user access to system data and controls, enabling data browsing, configuration management, and alert monitoring.  
  
- \*\*Interaction Method\*\*:   
 - Users interact with the system through browser-based forms, dashboards, and map displays.   
 - Data is dynamically rendered using \*\*Java Software Foundation (JSF)\*\* components.   
 - Real-time updates are provided via AJAX or WebSocket connections.   
 - Filtering, sorting, and visualization capabilities are integrated into the WUI for traffic, weather, and asset data.  
  
- \*\*Relevant Functional Requirements\*\*:   
 FR-17 (Traffic Information Browsing), FR-18 (Incident Information Browsing), FR-19 (Traveler Information Browsing), FR-20 (Asset Condition Information Browsing), FR-21 (Weather Information Browsing), FR-22 (Map Display), FR-23 (Icon Layer Management), FR-24 (De-Cluttering Capability), FR-28 (Presentation Method Adjustment), FR-37 (System Performance Monitoring), FR-46 (System Configuration Management), FR-51 (System Log Management), FR-52 (UserSession Management), FR-53 (AlertConfiguration Management), FR-54 (CacheEntry Management), FR-55 (ArchiveEntry Management)  
  
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### \*\*2.2 Hardware Interfaces\*\*  
  
The system interacts with various hardware devices to collect real-time data from the field.  
  
- \*\*2.2.1 Probe Vehicles\*\*   
 - \*\*Description\*\*:   
 Vehicles equipped with GPS and other sensors that provide real-time data on location, speed, travel time, and other parameters.   
 - \*\*Role\*\*:   
 Primary source of real-time traffic data and travel demand information.   
 - \*\*Interaction Method\*\*:   
 - Data is received via \*\*real-time data streams\*\* (e.g., TCP/IP or UDP protocols).   
 - The system validates and processes the data for integration into the Oracle 10g database.  
  
- \*\*2.2.2 Road Sensors\*\*   
 - \*\*Description\*\*:   
 Embedded or surface-mounted sensors that monitor road surface conditions (e.g., temperature, moisture, ice detection).   
 - \*\*Role\*\*:   
 Provide real-time data on road surface states to support road condition analysis and alerts.   
 - \*\*Interaction Method\*\*:   
 - Data is received via \*\*real-time data streams\*\* or \*\*modbus/RS-232\*\* serial communication.   
 - The system processes this data to infer road surface conditions and integrates it with other data sources.  
  
- \*\*2.2.3 Weather Stations\*\*   
 - \*\*Description\*\*:   
 Ground-based or remote sensing stations that collect environmental data such as temperature, precipitation, and visibility.   
 - \*\*Role\*\*:   
 Provide real-time weather data to support weather impact analysis on traffic and road conditions.   
 - \*\*Interaction Method\*\*:   
 - Data is received via \*\*real-time data streams\*\* or \*\*API calls\*\*.   
 - The system formats and stores the data in the Oracle 10g database for further use.  
  
- \*\*2.2.4 Map Displays\*\*   
 - \*\*Description\*\*:   
 Interactive digital displays used to visualize traffic, weather, and road condition data in a geographic context.   
 - \*\*Role\*\*:   
 Provide situational awareness to the Administrator and users via spatial data overlays.   
 - \*\*Interaction Method\*\*:   
 - Map data is rendered using \*\*Michigan Geographic Framework (MIGF)\*\*-aligned data.   
 - Map layers and icons are dynamically updated based on incoming data streams and system configurations.  
  
- \*\*Relevant Functional Requirements\*\*:   
 FR-02 (Traffic Data Collection), FR-05 (Road Surface Condition Calculation), FR-06 (Weather Observation Processing), FR-16 (MI Drive Presentation Support), FR-22 (Map Display), FR-23 (Icon Layer Management), FR-24 (De-Cluttering Capability), FR-34 (Michigan Geographic Framework Application)  
  
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### \*\*2.3 Software Interfaces\*\*  
  
The system interacts with various software systems and databases to process, store, and disseminate data.  
  
- \*\*2.3.1 Oracle 10g Database\*\*   
 - \*\*Description\*\*:   
 A relational database used for long-term data storage, retrieval, and indexing.   
 - \*\*Role\*\*:   
 Central repository for all processed data, including traffic metrics, incident details, road and weather conditions, and system logs.   
 - \*\*Interaction Method\*\*:   
 - The system uses \*\*JDBC (Java Database Connectivity)\*\* to establish and maintain a connection.   
 - Data is stored and retrieved using \*\*standard SQL queries\*\*.   
 - Data integrity and consistency are maintained through validation and caching mechanisms.   
 - Configuration data, logs, and alert settings are also stored in this database.  
  
- \*\*2.3.2 Traffic Management Systems (TMS)\*\*   
 - \*\*Description\*\*:   
 External systems responsible for managing traffic flow, controlling signals, and coordinating incident responses.   
 - \*\*Role\*\*:   
 Receive incident details and asset condition alerts for coordination of real-time traffic management.   
 - \*\*Interaction Method\*\*:   
 - Incident and asset condition data are \*\*published via standardized formats\*\* such as \*\*TMDD\*\* (Transportation Management Data Dictionary).   
 - Data is integrated into TMS for operational decision-making.  
  
- \*\*2.3.3 Traveler Information Systems (TIS)\*\*   
 - \*\*Description\*\*:   
 Systems that disseminate real-time traffic and weather information to travelers via digital signs, mobile apps, and web portals.   
 - \*\*Role\*\*:   
 Receive and display traffic alerts, incident details, and traveler advisories.   
 - \*\*Interaction Method\*\*:   
 - Data is \*\*pushed in real-time\*\* using \*\*SAE J2354\*\* and \*\*TMDD\*\* formats.   
 - The system ensures data is formatted and validated before dissemination.  
  
- \*\*2.3.4 Java Software Foundation (JSF)\*\*   
 - \*\*Description\*\*:   
 A Java-based framework used for building the system’s Web-Based User Interface.   
 - \*\*Role\*\*:   
 Enables dynamic rendering of user interface components and real-time data updates.   
 - \*\*Interaction Method\*\*:   
 - The system is \*\*built on the JSF architecture\*\*.   
 - Components are managed via \*\*JSF managed beans\*\* and \*\*Facelets templates\*\*.   
 - User interactions are processed through JSF lifecycle events and AJAX callbacks.  
  
- \*\*2.3.5 SAE J2354 Data Formatting\*\*   
 - \*\*Description\*\*:   
 A standard for exchanging traffic data between systems.   
 - \*\*Role\*\*:   
 Format processed data for integration with external systems and traveler information platforms.   
 - \*\*Interaction Method\*\*:   
 - Data is \*\*converted and validated against the SAE J2354 schema\*\*.   
 - Output is stored in the Oracle 10g database and sent to external systems for use.  
  
- \*\*2.3.6 TMDD (Transportation Management Data Dictionary) Data Formatting\*\*   
 - \*\*Description\*\*:   
 A standardized data format for traffic management system interoperability.   
 - \*\*Role\*\*:   
 Format and validate data for integration with Traffic Management Systems.   
 - \*\*Interaction Method\*\*:   
 - Data is \*\*converted and validated against the TMDD schema\*\*.   
 - Output is stored in the Oracle 10g database and sent to TMS for operational use.  
  
- \*\*2.3.7 Michigan Department of Information Technology (MDIT) Standards Compliance\*\*   
 - \*\*Description\*\*:   
 A set of state-defined standards for data formatting, storage, and dissemination.   
 - \*\*Role\*\*:   
 Ensure all data and system outputs comply with MDIT standards for audit and integration purposes.   
 - \*\*Interaction Method\*\*:   
 - Data is \*\*validated against MDIT compliance rules\*\* during processing.   
 - Compliance logs are stored in the Oracle 10g database for auditing.  
  
- \*\*Relevant Functional Requirements\*\*:   
 FR-02 (Traffic Data Collection), FR-03 (Traffic Metrics Analysis), FR-04 (Traffic Incident Inference), FR-05 (Road Surface Condition Calculation), FR-06 (Weather Observation Processing), FR-07 (Travel Demand Monitoring), FR-11 (Data Formatting for SAE J2354), FR-12 (Data Formatting for TMDD), FR-13 (Traffic Alert Publishing), FR-14 (Weather Alert Publishing), FR-15 (Asset Condition Alert Publishing), FR-29 (MDIT Standards Compliance), FR-30 (Java Software Foundation Integration), FR-31 (JDBC Database Connection), FR-32 (Oracle 10g Database Use), FR-33 (Standard SQL Query Execution), FR-46 (System Configuration Management), FR-47 (Historical Traffic Data Retrieval), FR-48 (Historical Weather Data Retrieval), FR-49 (Historical Road Condition Data Retrieval)  
  
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### \*\*2.4 Communication Interfaces\*\*  
  
The system communicates with external systems and services via various network protocols and message formats.  
  
- \*\*2.4.1 Real-Time Data Streams (TCP/IP or UDP)\*\*   
 - \*\*Description\*\*:   
 Network-based communication protocols used to receive live data from Probe Vehicles, Weather Stations, and Road Sensors.   
 - \*\*Role\*\*:   
 Enable the system to process and analyze real-time data for traffic and weather monitoring.   
 - \*\*Interaction Method\*\*:   
 - Data is \*\*received via socket-based communication\*\*.   
 - The system performs \*\*data validation and caching\*\* during high load or database unavailability.  
  
- \*\*2.4.2 API Calls for Weather Data\*\*   
 - \*\*Description\*\*:   
 External APIs used to fetch or validate weather data from Weather Stations or third-party weather services.   
 - \*\*Role\*\*:   
 Ensure the system can access up-to-date weather information for analysis and alert generation.   
 - \*\*Interaction Method\*\*:   
 - Weather data is \*\*retrieved via RESTful API calls\*\*.   
 - The system validates and integrates API responses into internal data models.  
  
- \*\*2.4.3 Message Publishing to Traveler Information Systems (TIS)\*\*   
 - \*\*Description\*\*:   
 Communication mechanism to send real-time alerts and traffic updates to TIS.   
 - \*\*Role\*\*:   
 Disseminate traffic alerts, weather advisories, and traveler information to the public.   
 - \*\*Interaction Method\*\*:   
 - Data is \*\*pushed via HTTP(S) or message queues\*\*.   
 - Output is formatted using \*\*SAE J2354\*\* or \*\*TMDD\*\* standards.  
  
- \*\*2.4.4 Web Browsing and Data Retrieval\*\*   
 - \*\*Description\*\*:   
 The system supports browsing and retrieving data via web-based interfaces.   
 - \*\*Role\*\*:   
 Allow users and administrators to access real-time and historical data remotely.   
 - \*\*Interaction Method\*\*:   
 - Users access the system via \*\*HTTP(S) web requests\*\*.   
 - Data is retrieved using \*\*standard SQL queries\*\* or \*\*predefined API endpoints\*\*.   
 - Web sessions are managed using \*\*UserSession\*\* data stored in the Oracle 10g database.  
  
- \*\*2.4.5 Email Notifications for System Alerts\*\*   
 - \*\*Description\*\*:   
 An optional communication method to notify administrators or stakeholders of critical system events.   
 - \*\*Role\*\*:   
 Provide real-time email alerts for incidents, weather hazards, and system issues.   
 - \*\*Interaction Method\*\*:   
 - The system \*\*sends email alerts via SMTP\*\* using predefined templates.   
 - Alert triggers are configured via \*\*AlertConfiguration\*\* settings.  
  
- \*\*2.4.6 Data Export and Import Interfaces\*\*   
 - \*\*Description\*\*:   
 Mechanisms to export and import data in standard formats for external use or integration.   
 - \*\*Role\*\*:   
 Enable data sharing with other departments or systems for reporting and analysis.   
 - \*\*Interaction Method\*\*:   
 - Data is \*\*exported in XML, JSON, or CSV\*\* based on user preferences.   
 - Import is supported via \*\*file uploads\*\* or \*\*API integrations\*\* for historical data or configuration updates.  
  
- \*\*Relevant Functional Requirements\*\*:   
 FR-02 (Traffic Data Collection), FR-05 (Road Surface Condition Calculation), FR-06 (Weather Observation Processing), FR-13 (Traffic Alert Publishing), FR-14 (Weather Alert Publishing), FR-15 (Asset Condition Alert Publishing), FR-25 (Data Source Addition), FR-30 (Java Software Foundation Integration), FR-33 (Standard SQL Query Execution), FR-38 (Traffic Report Generation), FR-39 (Weather Report Generation), FR-40 (Road Condition Report Generation), FR-51 (System Log Management)  
  
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### \*\*Summary of All Identified External Interfaces\*\*  
  
| Interface Name | Type | Description | Interaction Method | Related Functional Requirements |  
|----------------|------|-------------|---------------------|-------------------------------|  
| Web-Based User Interface | User Interface | Dynamic UI for data browsing, configuration, and monitoring | JSF with AJAX/WebSocket | FR-17 to FR-24, FR-46 to FR-55 |  
| Probe Vehicles | Hardware Interface | Provide real-time traffic data | TCP/IP, UDP, or API | FR-02, FR-07, FR-47 |  
| Road Sensors | Hardware Interface | Provide road surface condition data | TCP/IP, UDP, or serial communication | FR-05, FR-40 |  
| Weather Stations | Hardware Interface | Provide environmental and weather data | TCP/IP, UDP, or API | FR-06, FR-39 |  
| Map Displays | Hardware Interface | Visualize spatial data | MIGF-aligned rendering | FR-16, FR-22, FR-23 |  
| Oracle 10g Database | Software Interface | Central data storage and retrieval | JDBC, SQL queries | FR-02 to FR-10, FR-32 to FR-34, FR-47 to FR-55 |  
| Traffic Management Systems (TMS) | Software Interface | Receive and act on incident and asset data | TMDD-formatted data push | FR-04, FR-15 |  
| Traveler Information Systems (TIS) | Software Interface | Disseminate traffic and weather alerts | SAE J2354, TMDD-formatted data push | FR-13, FR-14, FR-16 |  
| Java Software Foundation (JSF) | Software Interface | UI framework for dynamic rendering | JSF managed beans and Facelets | FR-30 |  
| SAE J2354 Data Format | Software Interface | Standard for traveler information | Data formatting and schema validation | FR-11 |  
| TMDD Data Format | Software Interface | Standard for traffic management data | Data formatting and schema validation | FR-12 |  
| Michigan Geographic Framework (MIGF) | Software Interface | Spatial alignment and visualization | Coordinate mapping and overlay logic | FR-34 |  
| JDBC Connection | Software Interface | Database connectivity | JDBC driver and connection pooling | FR-31 |  
| Real-Time Data Streams | Communication Interface | Data from field devices | TCP/IP, UDP, or message queues | FR-02, FR-05, FR-06 |  
| API Calls | Communication Interface | Retrieve external data | RESTful or SOAP APIs | FR-06, FR-25 |  
| Message Publishing | Communication Interface | Send alerts to TIS | HTTP(S) or message queue | FR-13, FR-14, FR-15 |  
| Web Browsing | Communication Interface | Remote access to data | HTTP(S) requests | FR-17 to FR-21, FR-47 to FR-49 |  
| Email Notifications | Communication Interface | Alert administrators via email | SMTP-based email delivery | FR-13, FR-14, FR-15 |  
| Data Export/Import | Communication Interface | Share data with external systems | File export/import, API integration | FR-38, FR-39, FR-40, FR-46, FR-51 |  
  
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This section provides a comprehensive overview of all external interfaces the system must support. Developers and integrators can use this information to understand the system’s dependencies and to design appropriate integration points for each external component.