# Functional Requirement

1. Functional Requirements   
1.1 Vehicle Infrastructure Integration (VII) Data Use Analysis and Processing (DUAP) System   
 Function ID: FR-01   
 Description: The system must collect real-time data from probe vehicles, traffic management systems, weather stations, and traveler information systems. It should process and analyze the data to derive traffic metrics, infer incidents, calculate road surface conditions, and perform data quality checks.   
 Input: Real-time data from probe vehicles (speed, location, direction), traffic management systems (traffic signal status, incident reports), weather stations (temperature, humidity, wind speed), and traveler information systems (travel advisories).   
 Output: Updated traffic metrics (congestion levels, travel times, queue lengths), incident records, road surface condition assessments, and quality-checked data.  
  
1.2 Collect Traffic Data   
 Function ID: FR-02   
 Description: The system must collect and store real-time traffic data from probe vehicles, traffic management systems, and weather stations. It should synchronize the data with traffic metrics and perform data quality checks.   
 Input: Probe vehicle data (speed, location, direction), traffic management system data (incident reports, signal status), and weather station data (temperature, precipitation, visibility).   
 Output: Real-time traffic data stored in the system database (Oracle 10G), synchronized with traffic metrics and weather data.  
  
1.3 Analyze Traffic Metrics   
 Function ID: FR-03   
 Description: The system must analyze real-time and historical traffic data to derive metrics such as congestion levels, travel times, and queue lengths. It should detect incidents and generate alerts if necessary.   
 Input: Real-time and historical traffic data, weather data, and road condition data.   
 Output: Traffic metrics (congestion levels, travel times, queue lengths), incident details, and traffic alerts for dissemination to relevant systems.  
  
1.4 Infer Traffic Incidents   
 Function ID: FR-04   
 Description: The system must analyze traffic data to detect and infer potential traffic incidents. It should log incident details, generate alerts, and update the web-based user interface for visualization.   
 Input: Traffic data (speed, queue lengths, congestion levels), weather data, and road surface condition data.   
 Output: Incident records (incident type, location, severity, duration), traffic alerts, and updated map displays on the web interface.  
  
1.5 Calculate Road Surface Conditions   
 Function ID: FR-05   
 Description: The system must integrate probe vehicle data, weather data, and traffic data to calculate road surface conditions. It should validate the results against historical data and generate alerts for hazardous conditions.   
 Input: Probe vehicle data (speed, brake usage), weather data (temperature, precipitation), and traffic data (road condition sensors).   
 Output: Road surface condition assessments (condition type, severity), alerts for hazardous conditions, and updated map displays.  
  
1.6 Monitor Weather Observations   
 Function ID: FR-06   
 Description: The system must monitor real-time weather data from weather stations and integrate it with traffic and road condition data for comprehensive analysis. It should generate weather alerts and update the web-based interface.   
 Input: Real-time weather data (temperature, wind speed, visibility), probe vehicle data, and road condition data.   
 Output: Integrated weather and traffic data, weather alerts, and updated weather displays on the web interface.  
  
1.7 Track Travel Demand   
 Function ID: FR-07   
 Description: The system must calculate and track travel demand based on real-time and historical traffic data, weather conditions, and congestion levels. It should generate travel demand forecasts and alerts if demand exceeds capacity thresholds.   
 Input: Traffic data (congestion levels, travel times), weather data, and historical traffic patterns.   
 Output: Travel demand forecasts, traffic alerts for high demand, and updated traveler information for dissemination.  
  
1.8 Perform Data Quality Checks   
 Function ID: FR-08   
 Description: The system must validate all incoming data (traffic, weather, road condition) for accuracy, consistency, and completeness. It should log invalid data and exclude it from further processing.   
 Input: Traffic data, weather data, and road condition data.   
 Output: Validated data stored in the database, logs of invalid or corrupted data, and data quality check status updates on the web interface.  
  
1.9 Implement Dynamic Data Caching   
 Function ID: FR-09   
 Description: The system must cache frequently accessed and critical data (e.g., traffic metrics, road surface conditions) to improve performance and reduce latency. It should refresh the cache periodically and provide fallback to the database when needed.   
 Input: Real-time data (traffic metrics, road surface conditions, weather observations).   
 Output: Cached data for quick access, updated web interface with cached data, and logs of caching operations.  
  
1.10 Archive Data for Long-Term Storage   
 Function ID: FR-10   
 Description: The system must archive processed data (traffic metrics, weather data, incident details) for long-term storage. It should ensure compliance with data standards and maintain data integrity during archiving.   
 Input: Processed data (traffic metrics, incident details, road surface conditions).   
 Output: Archived data in the Oracle 10G database, logs of archiving operations, and metadata for traceability.  
  
1.11 Format Data According to Standards   
 Function ID: FR-11   
 Description: The system must format processed data to comply with predefined standards (e.g., SAE J2354, TMDD) for external integration. It should validate the data structure and ensure compatibility with external systems.   
 Input: Processed data (traffic metrics, weather observations, incident details).   
 Output: Formatted data for external systems (e.g., Traveler Information Systems, Traffic Management Systems) and logs of formatting operations.  
  
1.12 Process Traffic and Weather Alerts   
 Function ID: FR-12   
 Description: The system must generate, process, and disseminate traffic and weather alerts based on predefined thresholds. It should update the web-based interface and ensure alerts are prioritized based on severity.   
 Input: Real-time traffic and weather data, alert thresholds, and system status.   
 Output: Traffic and weather alerts sent to relevant systems, alerts displayed on the web interface, and logs of alert generation and delivery.  
  
1.13 Publish Traffic Alerts   
 Function ID: FR-13   
 Description: The system must publish traffic alerts to Traffic Management Systems and Traveler Information Systems. It should update the web interface and archive the alerts for compliance.   
 Input: Traffic incident data, alert content, and approval status from the Administrator.   
 Output: Published traffic alerts, updated web interface with alert visuals, and archived alerts for future reference.  
  
1.14 Publish Weather Event Alerts   
 Function ID: FR-14   
 Description: The system must generate and publish weather event alerts (e.g., snow, heavy rain) to Traffic Management Systems and Traveler Information Systems. It should update the web interface and archive the alerts.   
 Input: Weather event data (precipitation, visibility, temperature), alert thresholds, and approval status.   
 Output: Published weather event alerts, updated web interface, and archived alerts for compliance.  
  
1.15 Publish Asset Condition Alerts   
 Function ID: FR-15   
 Description: The system must detect and publish asset condition alerts (e.g., road damage, signal malfunction) to Traffic Management Systems and Traveler Information Systems. It should update the web interface and archive the alerts.   
 Input: Asset condition data (infrastructure status, signal status, road damage), alert thresholds, and approval status.   
 Output: Published asset condition alerts, updated web interface, and archived alerts for compliance.  
  
1.16 Support MI Drive Presentation Data   
 Function ID: FR-16   
 Description: The system must generate MI Drive presentation data from processed traffic, weather, and road condition data. It should format and validate the data for external use and update the web interface for visualization.   
 Input: Processed data (traffic metrics, weather data, road surface conditions).   
 Output: MI Drive presentation data for external systems, updated web interface with presentation data, and archived presentation data.  
  
1.17 Provide Web-Based User Interface   
 Function ID: FR-17   
 Description: The system must provide a web-based user interface for browsing traffic, weather, and road condition data. It should support map displays, icon layers, and decluttering features for real-time visualization.   
 Input: Real-time and processed data (traffic metrics, weather observations, incident details).   
 Output: Updated web interface with map displays, icon layers, and decluttering features for visualization.  
  
1.18 Display Map Views   
 Function ID: FR-18   
 Description: The system must display real-time traffic, weather, and road condition data on map views. It should use the Michigan Geographic Framework for geo-referencing and apply decluttering features for clarity.   
 Input: Real-time data (traffic metrics, weather observations, road conditions), map configuration settings.   
 Output: Real-time map displays with data overlays, decluttering features applied, and logs of map rendering operations.  
  
1.19 Manage Icon Layers   
 Function ID: FR-19   
 Description: The system must allow the Administrator to manage icon layers on the web-based interface. It should support toggling visibility, adjusting priority, and modifying appearance for different data types.   
 Input: Icon layer configuration parameters (data type, visibility, priority, appearance).   
 Output: Updated icon layer settings on the web interface, logs of configuration changes, and synchronized map displays.  
  
1.20 Enable De-Cluttering Features   
 Function ID: FR-20   
 Description: The system must enable decluttering features to reduce visual overload on the web-based interface. It should dynamically adjust the display based on user preferences and data density.   
 Input: Decluttering rules (data density thresholds, priority-based filtering).   
 Output: Decluttered map displays, logs of decluttering settings, and real-time updates with decluttering logic.  
  
1.21 Add New Data Sources   
 Function ID: FR-21   
 Description: The system must allow the Administrator to add new data sources (e.g., probe vehicles, weather stations, traffic management systems) and configure them for integration.   
 Input: Data source details (type, communication protocol, data format, location).   
 Output: New data sources integrated into the system, updated data processing, and logs of source additions.  
  
1.22 Update Data Processing Algorithms   
 Function ID: FR-22   
 Description: The system must allow the Administrator to update or replace data processing algorithms. It should perform a test run with historical data before deployment.   
 Input: Algorithm details (name, description, file, test data).   
 Output: Updated data processing algorithms, logs of algorithm changes, and synchronized data processing.  
  
1.23 Modify Output Formats   
 Function ID: FR-23   
 Description: The system must allow the Administrator to modify the output format of data (e.g., CSV, JSON, XML) to ensure compatibility with external systems.   
 Input: Output format parameters (data type, format name, schema).   
 Output: Modified output formats, updated data exports, and logs of format changes.  
  
1.24 Integrate New Presentation Methods   
 Function ID: FR-24   
 Description: The system must allow the Administrator to integrate new presentation methods (e.g., 3D maps, heatmaps, animated traffic flow) for improved data visualization.   
 Input: Presentation method details (name, description, visualization type, data sources).   
 Output: New presentation methods integrated into the web interface, logs of method changes, and updated visualization options.  
  
1.25 Comply with MDIT Standards   
 Function ID: FR-25   
 Description: The system must ensure all processed data complies with MDIT standards. It should format and validate data to maintain interoperability with external systems.   
 Input: Processed data (traffic metrics, weather observations, incident details).   
 Output: Compliant data stored in the database, logs of compliance checks, and updated web interface with compliance status.  
  
1.26 Utilize Java Software Foundation   
 Function ID: FR-26   
 Description: The system must process and store data using the Java Software Foundation framework. It should maintain compatibility with JDBC and Oracle 10G for database access.   
 Input: Real-time data (traffic, weather, road condition data), Java-based processing rules.   
 Output: Java-based data processing and storage, logs of Java operations, and updated web interface with Java-generated visualizations.  
  
1.27 Use JDBC for Database Access   
 Function ID: FR-27   
 Description: The system must use JDBC to access and update data in the Oracle 10G database. It should maintain secure and efficient database transactions.   
 Input: SQL queries and database connection parameters (host, port, credentials).   
 Output: Database operations (insert, update, delete), logs of JDBC transactions, and synchronized data with the database.  
  
1.28 Manage Oracle 10G Database   
 Function ID: FR-28   
 Description: The system must allow the Administrator to manage Oracle 10G database operations (insert, update, delete, query). It should maintain data integrity and performance.   
 Input: Database operation details (SQL commands, data to insert/update/delete).   
 Output: Updated Oracle 10G database records, logs of database operations, and synchronized data with the web interface.  
  
1.29 Execute Standard SQL Queries   
 Function ID: FR-29   
 Description: The system must allow the Administrator to execute standard SQL queries to retrieve data for analysis or reporting.   
 Input: SQL query text, data source and format preferences.   
 Output: Query results displayed on the web interface, logs of executed queries, and archived query results.  
  
1.30 Apply Michigan Geographic Framework for Geo-Referencing   
 Function ID: FR-30   
 Description: The system must geo-reference all data using the Michigan Geographic Framework. It should ensure accurate mapping of data points for real-time visualization.   
 Input: Data with location information (vehicle location, incident location, weather station location).   
 Output: Geo-referenced data for mapping, updated web interface with geographic data, and logs of geo-referencing operations.  
  
1.31 Maintain Incident Details   
 Function ID: FR-31   
 Description: The system must allow the Administrator to update, view, or delete incident details (e.g., location, severity, duration). It should synchronize the data with traffic and weather information.   
 Input: Incident details (location, severity, duration), update or delete actions.   
 Output: Updated incident records in the database, logs of incident management, and synchronized web interface with incident data.  
  
1.32 Update Traffic Management Systems   
 Function ID: FR-32   
 Description: The system must update Traffic Management Systems with the latest traffic data, alerts, and road conditions. It should format the data according to predefined standards and ensure synchronization.   
 Input: Traffic data (congestion levels, incident details, road surface conditions).   
 Output: Updated Traffic Management Systems, logs of update operations, and archived data for compliance.  
  
1.33 Retrieve Traveler Information   
 Function ID: FR-33   
 Description: The system must retrieve and format traveler information (e.g., travel times, congestion levels, route suggestions) for dissemination to Traveler Information Systems.   
 Input: Traffic data, weather data, and road condition data.   
 Output: Traveler information formatted and sent to external systems, logs of retrieval operations, and updated web interface.  
  
1.34 Manage Probe Vehicle Data   
 Function ID: FR-34   
 Description: The system must process and manage probe vehicle data (speed, location, heading). It should perform quality checks and update traffic metrics and road condition assessments.   
 Input: Probe vehicle data (speed, location, heading), quality check rules.   
 Output: Validated and stored probe vehicle data, updated traffic metrics, and logs of probe data processing.  
  
1.35 Update Infrastructure Information   
 Function ID: FR-35   
 Description: The system must allow the Administrator to update infrastructure data (e.g., road status, signal status, signage changes). It should synchronize the data with traffic and weather systems.   
 Input: Infrastructure update details (location, status, configuration).   
 Output: Updated infrastructure data in the database, synchronized web interface, and logs of infrastructure changes.  
  
1.36 View Traffic Status   
 Function ID: FR-36   
 Description: The system must allow the Administrator to view real-time traffic status (e.g., congestion levels, travel times, queue lengths) on the web-based interface.   
 Input: Real-time traffic data and historical data.   
 Output: Traffic status displayed on the web interface, logs of viewing activity, and synchronized data for analysis.  
  
1.37 View Weather Data   
 Function ID: FR-37   
 Description: The system must allow the Administrator to view real-time weather data (e.g., temperature, visibility, wind speed) on the web-based interface.   
 Input: Real-time weather data from weather stations.   
 Output: Weather data displayed on the web interface, logs of viewing activity, and synchronized weather and traffic data.  
  
1.38 View Road Condition Data   
 Function ID: FR-38   
 Description: The system must allow the Administrator to view real-time road condition data (e.g., road surface conditions, incident details) on the web-based interface.   
 Input: Road condition data (surface type, severity), incident data.   
 Output: Road condition data displayed on the web interface, logs of viewing activity, and synchronized data for traveler advisories.  
  
1.39 View Incident Reports   
 Function ID: FR-39   
 Description: The system must allow the Administrator to view and manage incident reports (e.g., incident type, location, severity) on the web-based interface.   
 Input: Incident data (type, location, severity), filtering parameters.   
 Output: Incident reports displayed on the web interface, logs of viewing activity, and synchronized data for alerting.  
  
1.40 View Asset Conditions   
 Function ID: FR-40   
 Description: The system must allow the Administrator to view asset conditions (e.g., infrastructure status, signal malfunctions) on the web-based interface.   
 Input: Asset condition data (status, location, type), filtering parameters.   
 Output: Asset conditions displayed on the web interface, logs of viewing activity, and synchronized data for alerting.  
  
1.41 Delete Outdated Data   
 Function ID: FR-41   
 Description: The system must allow the Administrator to delete outdated data (e.g., expired traffic metrics, old incident records) to maintain database performance and relevance.   
 Input: Criteria for outdated data (time threshold, data type).   
 Output: Deleted outdated data from the database, logs of deletion operations, and archived data for compliance.  
  
1.42 Modify User Interface Settings   
 Function ID: FR-42   
 Description: The system must allow the Administrator to modify web-based interface settings (e.g., map display options, icon layer visibility). It should apply the changes and update the interface for real-time visualization.   
 Input: Interface configuration parameters (map display, icon layer, decluttering settings).   
 Output: Updated web interface settings, logs of configuration changes, and synchronized data visualization.  
  
1.43 Manage Administrative Tasks   
 Function ID: FR-43   
 Description: The system must allow the Administrator to manage system tasks (e.g., data deletion, configuration updates, alert management). It should ensure task execution without disrupting real-time operations.   
 Input: Administrative task parameters (task type, data, configuration).   
 Output: Updated system configuration, logs of administrative tasks, and synchronized data and interface.  
  
1.44 Maintain System Configuration   
 Function ID: FR-44   
 Description: The system must allow the Administrator to update system configuration parameters (e.g., data sources, alert thresholds, caching rules). It should validate the changes and apply them to the system.   
 Input: Configuration parameters (data source settings, alert rules, cache settings).   
 Output: Updated system configuration, logs of configuration changes, and synchronized data and interface.  
  
1.45 Manage Data Entities Lifecycle   
 Function ID: FR-45   
 Description: The system must manage the lifecycle of data entities (create, update, archive, delete) to ensure data integrity and compliance. It should log all lifecycle operations for audit purposes.   
 Input: Data entity type and action (create, update, archive, delete).   
 Output: Updated data entity records, logs of lifecycle operations, and synchronized data and interface.  
  
1.46 Manage Data Processing Algorithm   
 Function ID: FR-46   
 Description: The system must allow the Administrator to manage data processing algorithms (add, update, delete). It should perform test runs and ensure compatibility before deployment.   
 Input: Algorithm details (name, description, file, test data).   
 Output: Updated algorithm configurations, logs of algorithm management, and synchronized data processing.  
  
1.47 Manage Data Format   
 Function ID: FR-47   
 Description: The system must allow the Administrator to manage data output formats (add, update, delete). It should ensure compatibility with external systems and standards.   
 Input: Data format parameters (name, schema, data type).   
 Output: Updated data format settings, logs of format changes, and synchronized data exports.  
  
1.48 Manage Presentation Method   
 Function ID: FR-48   
 Description: The system must allow the Administrator to manage presentation methods (add, update, delete) for the web interface. It should ensure compatibility with data visualization tools.   
 Input: Presentation method details (name, description, visualization type).   
 Output: Updated presentation methods, logs of method changes, and synchronized web interface visualization.  
  
1.49 Manage Data Cache   
 Function ID: FR-49   
 Description: The system must allow the Administrator to manage dynamic data cache settings (size, refresh frequency, eviction policies). It should ensure optimal performance and data accuracy.   
 Input: Cache configuration parameters (cache size, refresh interval, eviction policy).   
 Output: Updated cache settings, logs of cache management, and synchronized data access and performance.  
  
1.50 Manage ArchiveRecord   
 Function ID: FR-50   
 Description: The system must allow the Administrator to manage ArchiveRecord entries (add, update, delete) for long-term storage. It should maintain data integrity and compliance.   
 Input: ArchiveRecord details (data type, archive date, metadata).   
 Output: Updated ArchiveRecord entries, logs of archive management, and synchronized data storage.  
  
1.51 Manage AlertConfiguration   
 Function ID: FR-51   
 Description: The system must allow the Administrator to manage alert configurations (add, update, delete). It should ensure alerts are generated based on valid thresholds and rules.   
 Input: Alert configuration parameters (alert type, threshold, trigger time).   
 Output: Updated alert configurations, logs of alert management, and synchronized alert generation.  
  
1.52 Manage VII System   
 Function ID: FR-52   
 Description: The system must allow the Administrator to manage VII system configurations (add, update, delete data sources, integration rules). It should ensure system stability and data flow.   
 Input: VII system configuration parameters (data source details, integration rules).   
 Output: Updated VII system configurations, logs of system changes, and synchronized data integration.  
  
1.53 Manage DUAP   
 Function ID: FR-53   
 Description: The system must allow the Administrator to manage DUAP configurations (add, update, delete modules, algorithms, or processing rules). It should ensure data processing aligns with updated settings.   
 Input: DUAP configuration parameters (module name, algorithm version, data source mapping).   
 Output: Updated DUAP settings, logs of configuration changes, and synchronized data processing.  
  
1.54 Manage Probe Vehicles   
 Function ID: FR-54   
 Description: The system must allow the Administrator to manage probe vehicle configurations (add, update, delete, activate/deactivate). It should ensure accurate and reliable data collection.   
 Input: Probe vehicle configuration parameters (vehicle ID, communication protocol, data format).   
 Output: Updated probe vehicle configurations, logs of management operations, and synchronized data collection.  
  
1.55 Manage Traffic Management Systems   
 Function ID: FR-55   
 Description: The system must allow the Administrator to manage Traffic Management System configurations (add, update, delete). It should ensure data exchange and synchronization.   
 Input: Traffic Management System configuration parameters (system ID, communication endpoint, data format).   
 Output: Updated Traffic Management System configurations, logs of system changes, and synchronized data flow.  
  
1.56 Manage Weather Stations   
 Function ID: FR-56   
 Description: The system must allow the Administrator to manage weather station configurations (add, update, delete). It should ensure accurate weather data collection and integration.   
 Input: Weather station configuration parameters (station ID, communication protocol, data format).   
 Output: Updated weather station configurations, logs of station changes, and synchronized weather data.  
  
1.57 Manage Traveler Information Systems   
 Function ID: FR-57   
 Description: The system must allow the Administrator to manage Traveler Information System configurations (add, update, delete). It should ensure real-time data dissemination to travelers.   
 Input: Traveler Information System configuration parameters (system ID, communication endpoint, data format).   
 Output: Updated Traveler Information System configurations, logs of system changes, and synchronized data delivery.  
  
1.58 Manage Data Quality Checks   
 Function ID: FR-58   
 Description: The system must allow the Administrator to manage data quality check rules (add, update, delete). It should ensure data integrity and exclude invalid data from processing.   
 Input: Data quality check parameters (rule name, validation criteria, threshold values).   
 Output: Updated quality check rules, logs of rule management, and synchronized data validation.

# External Description

2. External Interfaces  
  
2.1 User Interface   
The system provides a web-based user interface (Web UI) for real-time data visualization and system administration. The Web UI supports map displays, icon layers for traffic, weather, and road conditions, and decluttering features to enhance readability and usability. The interface allows the Administrator to manage configurations, view traffic status, weather data, and road conditions, and perform tasks such as adding new data sources, updating algorithms, and modifying output formats. The Web UI also displays traffic alerts, weather alerts, and asset condition alerts, ensuring that users receive up-to-date information for decision-making and system monitoring.  
  
2.2 Hardware Interface   
The system interfaces with various hardware components to collect real-time data:  
  
- \*\*Probe Vehicles\*\*: These vehicles provide real-time data such as speed, location, and direction. The system communicates with them via predefined data formats and communication protocols (e.g., TCP/IP, HTTP).   
- \*\*Traffic Management Systems (TMS)\*\*: These systems provide traffic signal status and incident reports. The system integrates with TMS using standard data formats and communication protocols to ensure seamless data exchange.   
- \*\*Weather Stations\*\*: The system receives weather data (e.g., temperature, humidity, wind speed, visibility, precipitation) from weather stations. Communication is typically through APIs or data feeds, using standard formats such as XML or JSON.   
- \*\*Road Condition Sensors\*\*: These sensors provide data on road surface conditions, including temperature and moisture levels. The system uses standardized communication protocols to integrate this data into its analysis.   
  
These hardware interfaces are essential for collecting and processing real-time data, enabling accurate traffic and weather monitoring.  
  
2.3 Software Interface   
The system interacts with several external software systems and databases:  
  
- \*\*Oracle 10G Database\*\*: The system uses this database for storing and retrieving traffic, weather, road condition, and incident data. Data is accessed via JDBC for secure and efficient transactions.   
- \*\*Traffic Management Systems (TMS) Software\*\*: The system sends and receives data from TMS software to update traffic metrics and incident records. Data is formatted according to standards such as TMDD and SAE J2354 for interoperability.   
- \*\*Traveler Information Systems (TIS) Software\*\*: The system disseminates traveler information (e.g., travel times, route suggestions, congestion levels) to TIS software. Data is formatted for compatibility with TIS platforms.   
- \*\*Java Software Foundation (JSF) Framework\*\*: The system uses JSF for data processing and storage. It ensures compatibility with Java-based components and supports dynamic data caching.   
- \*\*Third-Party Data Visualization Tools\*\*: The system integrates with tools that support 3D maps, heatmaps, and animated traffic flow for enhanced data presentation. These tools are configured through the web interface by the Administrator.   
- \*\*Data Formatting and Validation Tools\*\*: The system employs tools to format processed data according to predefined standards (e.g., SAE J2354, TMDD) and validate the data structure for external use.   
  
These software interfaces ensure that the system can process, store, and disseminate data efficiently and in a standardized format.  
  
2.4 Communication Interface   
The system supports various communication interfaces to facilitate data exchange between components and external systems:  
  
- \*\*Web Browsing\*\*: Users access the web-based interface via standard web browsers (e.g., Chrome, Firefox). This interface supports real-time data visualization and administrative tasks.   
- \*\*API Communication\*\*: The system communicates with external systems (e.g., TMS, TIS, weather stations) using APIs. These APIs support data retrieval and dissemination, ensuring compatibility with external systems.   
- \*\*Email Notifications\*\*: The system can send email notifications for critical alerts (e.g., traffic incidents, weather events, asset conditions). These emails are generated based on predefined alert severity levels and are sent to designated recipients.   
- \*\*Message Push Services\*\*: The system supports message push to external systems for real-time updates (e.g., traffic alerts, weather advisories). These messages are formatted according to standard protocols and are delivered via secure channels.   
- \*\*Data Feeds\*\*: The system receives and sends data feeds from and to external sources (e.g., probe vehicles, weather stations) using standardized formats and protocols. These data feeds are synchronized with internal data processing and visualization.   
  
The communication interfaces ensure that the system can interact with external entities in a timely and secure manner, supporting real-time data flow and system integration.