I-210 “ICM California” Pilot Site

- Executive Summary
- Integrated Corridor Management (ICM)
- Connected Corridors Program
- ICM California: I-210 Demonstration Site
- Discussion
Executive Summary

- Federal/State programs launched to encourage demonstrable transportation network improvements in safety, performance, reliability and environmental sustainability.
  - USDOT launches 7-year Integrated Corridor Management (ICM) initiative
  - CTC requests Corridor System Management Plans
  - MAP-21 – Requires measurement and validation of improvements
  - SHRP2 – Recommends capability maturity model (CMM) for projects

- To meet the requirements set forth in these initiatives, Caltrans sets system management goals including leading the day to day management of major California corridors, in tight integration with MPOs, cities and counties.

- Day to day traffic management includes:
  - *proactive real time* supply management (ramp metering, signal light synchronization, guided rerouting, improved incident response, etc)
  - *proactive* demand management (mode, travel time and re-routing)
Executive Summary

- **Goal:** Caltrans will lead the planning, implementation and ongoing operational support for 50 corridor segments in California – “ICM California”

- **“I-210 Pilot”** – The first Caltrans-lead ICM effort in California and the first corridor site in the “ICM California” plan. (Not yet official)

- **“Connected Corridors”** – The multi organizational program tasked with delivering all reusable components of “ICM California.”

- **Next Step:** Connected Corridors–VIP (Vehicles, Information and People) positions Caltrans for autonomous/connected vehicles, social network coordination and ultimately integration with future Smart City initiatives.

- Your support and understanding is key
Integrated Corridor Management (ICM)

- What is Integrated Corridor Management (ICM)?
- Caltrans’ System Management Goals + Related Programs
- Existing ICM Efforts and Strategies
ICM – Integrated Corridor Management

- While the ICM term is well known, various existing management efforts already support the ICM concept, particularly ITS applications
  - **Active Traffic and Demand Management (ATDM) systems** is the dynamic management, control, and influence of travel demand, traffic demand, and traffic flow of transportation facilities.
  - **Advanced public transportation system (APTS)**, such as automated vehicle tracking, dynamic schedule adjustments, bus rapid transit
  - **Advanced traffic management system (ATMS)**, such as traffic-responsive and real-time signal control systems
  - **Advanced traveler information systems (ATIS)**, such as real-time traveler information systems, dynamic navigation systems

- The key to ICM is integrating existing systems and management efforts with new concepts and relationships to develop a coherent multi-modal, multi-jurisdiction, corridor-wide transportation management system
Typical ICM Corridor

**Stakeholders**

- State DOT — Freeway Management
- Local Jurisdictions — Arterial & local traffic management
- Transit Agencies — Bus, rail and other public transportation
- Parking operators
- Information service providers
- Potentially many mores...

**Travel Alternatives**

- Persons
- Goods

**Map Symbols**

- P: Publicly operated parking
- Private operated parking
- Bus stop
- Light rail station
- Airport
- Freeway
- Interchange
- Primary arterials
- Secondary arterials
- Rail line (freight)
- Business Park
- Mall
- Sports Stadium
California’s Progress towards ICM ...

- $20B transportation bond in 2006
- California Transportation Commission is on-board
  - Demand science based reasoning for project selection
  - Require to consider the use of technology as a cost effective investment
  - Allocate over $100M to ITS projects
- $4.5B for Corridor Mobility Improvement (CMIA)
- Corridor System Management Plans (CSMPs) required on all CMIA corridors
  - CSMPs developed for over 50 freeway corridors
  - 31 using microscopic traffic simulation to assess impacts of improvements
  - Simulations and scientific assessments point to ITS elements as being among most cost effective investments
Caltrans System Management Goals

1. Create a system management culture

2. Performance-based framework for all TMS work activities and funding prioritization

3. Establish a well-maintained and high-performing TMS infrastructure that supports real-time traffic management

4. Cooperatively develop and implement real-time (active) traffic management to optimize flow, safety and aid regions and the State to meet greenhouse gas reduction (GHG) targets from transportation

5. Renew consensus on and adhere to critical statewide standards
# System Management Vision

<table>
<thead>
<tr>
<th>System Management</th>
<th>Current State</th>
<th>Future State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems Tools and Functions</td>
<td>Separated</td>
<td>Integrated</td>
</tr>
<tr>
<td>Data &amp; Information</td>
<td>Historical</td>
<td>Real-Time</td>
</tr>
<tr>
<td>Decision &amp; Business Process</td>
<td>Reactive</td>
<td>Proactive/Predictive</td>
</tr>
<tr>
<td>Resources</td>
<td>Static Assignment</td>
<td>Dynamic Assignment</td>
</tr>
</tbody>
</table>
USDOT ICM Initiative

FY06 | FY07 | FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 | FY16

Stakeholder working group

Phase 1 – Foundational Research

Phase 2 – Corridor tools, strategies and integration

Phase 2 Feedback: Tool development, guidance, planning

ConOps & SyRS

Phase 3 – Pioneer Sites

Analysis, Modeling, and Simulation

Demonstration

Phase 3 - Evaluation

Pre-deployment | Post-

Phase 4: Knowledge and Technology Transfer

Awareness | Understanding | Equip practitioners | Long term
Effect of MAP-21 Requirements

- **Outcome-driven approach tracking performance**
  - USDOT to establish performance measures
  - State DOTs to develop performance targets in consultation with Metropolitan Planning Organizations and others
  - Utilization of performance targets expected to provide agencies with an effective tool to help allocate limited resources towards effective improvement projects

- **Areas for which performance measures are to be defined include**
  - Safety
  - Infrastructure condition
  - Congestion reduction
  - System reliability
  - Freight movement and economic vitality
  - Environmental sustainability
  - Reduced project delivery delays
SHRP2 – Strategic Highway Research Program

- Focused on planning, reliability, safety and renewal
- Recommends Capability Maturity Model (CMM)

## Basic Institutional Capability Maturity Elements and Levels

<table>
<thead>
<tr>
<th>Institutional Elements</th>
<th>Level 1 Ad Hoc</th>
<th>Level 2 Rationalized</th>
<th>Level 3 Mainstreamed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture/leadership</td>
<td>Mixed, hero driven</td>
<td>Championed/ internalized across disciplines</td>
<td>Commitment to customer mobility</td>
</tr>
<tr>
<td>Organization and staffing</td>
<td>Fragmented, understaffed</td>
<td>Aligned, trained</td>
<td>Integrated</td>
</tr>
<tr>
<td>Resource allocation</td>
<td>Project level</td>
<td>Criteria-based program</td>
<td>Sustainable budget line item</td>
</tr>
<tr>
<td>Partnerships</td>
<td>Informal, unaligned</td>
<td>Formal, aligned</td>
<td>Consolidated</td>
</tr>
</tbody>
</table>

Source: SHRP2 S2-L06-RR-2 Report
## ICM Projects – United States

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Corridor Type</th>
<th>Lead Agencies</th>
<th>Activities</th>
</tr>
</thead>
</table>
| I-15 Diego        | Suburban          | SANDAG        | • ConOps and System Requirements developed in 2008  
|                   |                   |               | • Simulation evaluation in 2009-2010                               |
|                   |                   |               | • System launched in spring 2013                                    |
|                   |                   |               | • Currently in evaluation phase                                   |
| US-75 Dallas      | Suburban/urban    | DART          | • ConOps and System Requirements developed in 2008  
|                   |                   |               | • Simulation evaluation in 2009-2010                               |
|                   |                   |               | • System launched in spring 2013                                    |
|                   |                   |               | • Currently in evaluation phase                                   |
| I-80 Bay Area     | Suburban/urban    | MTC / Caltrans| • ConOps developed in 2010                                            |
|                   |                   |               | • Project groundbreaking in October 2012                            |
|                   |                   |               | • Project expected to be completed summer 2015                      |
| I-95 / I-395      | Rural, Suburban & | Virginia DOT  | • ConOps development initiated in 2012                               |
| Virginia          | Urban             |               | • Currently developing deployment plan & partnerships               |
| I-394 Minneapolis | Suburban/urban    | Minnesota DOT | • ConOps and System Requirements developed in 2008  
|                   |                   |               | • Simulation evaluation in 2009                                     |
|                   |                   |               | • No apparent activity since 2009                                   |
| I-270 Maryland    | Suburban          | Maryland DOT  | • ConOps and System Requirements developed in 2008  
|                   |                   |               | • No apparent activity since 2008                                   |
ICM Element Examples

- **Enhanced traffic monitoring systems**
  - Collection of real-time freeway, arterial, transit and weather data

- **Enhanced communication**
  - Data sharing capabilities among agencies
  - Information service provider access to select datasets

- **Freeway operations**
  - Traffic-responsive ramp metering
  - Coordination of ramp meters with arterial traffic signals
  - Dynamic HOV/HOT restrictions
  - Ramp queue warning
  - Variable advisory speeds
  - Dynamic Lane use control
  - Dynamic hard shoulder running
ICM Element Examples

- **Arterial operations**
  - Traffic-responsive signal control
  - Transit signal priority
  - Emergency preemption

- **Enhanced traveler information**
  - Multi-modal 511 systems
  - Real-time traffic/transit/parking info
  - Comparative trips across modes
  - Freeway CMSs
  - Arterial trailblazer signs
  - Mobile travel information applications
  - Social media links

- **Decision support system**
  - Automated response plan development
  - Evaluation of impacts using simulation
ICM Projects – International

<table>
<thead>
<tr>
<th>Corridor</th>
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<th>Activities</th>
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</thead>
<tbody>
<tr>
<td>M1 Freeway, Melbourne (Australia)</td>
<td>Suburban / Urban</td>
<td>• Deployment of traffic management and traveler information systems along the freeway and freeway ramps</td>
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<tr>
<td>M42 Freeway, Birmingham (UK)</td>
<td>Suburban / Rural</td>
<td>• Deployment of traffic management and traveler information systems along the freeway and freeway ramps</td>
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</tbody>
</table>

No documented evidence of active projects seeking to integrate the control of freeways and neighboring arterials
Connected Corridors

- Definition
- Tools and Techniques
- Integration defined
Enable existing transportation infrastructure and vehicles to work together in a highly coordinated manner

Deliver improved corridor performance (safety and mobility)

Improve accountability

Evolve Caltrans to Real-Time operations and management

Enhance regional, local and private sector partnerships
What is Connected Corridors?

- Program comprised of a **number of efforts in partnership** with various agencies and industry partners

- Tasked with:
  - Developing methods and tools for how transportation corridors will be managed in California (Connected Corridors templates)
  - Advancing and integrating technologies needed for corridor management
  - Planning for Caltrans district level organizational support for ICM
  - Identifying and securing funding
  - Providing strategic and tactical education on corridor management
  - Implementing a pilot showcasing the above elements
  - Facilitating the implementation of ICM in multiple corridors in California
Connected Corridor History

3 years ago

- Active traffic management gains acceptance with John Wolf and others in response to growth of both ITS capabilities and ballooning construction costs
- Connected Corridors program / ICM California envisioned

2 years ago

- Program officially started with joint effort between Caltrans and PATH/CCIT
- Joan Sollenberger assumes leadership role
- Decision support development started with best of breed from TOPL, Mobile Millennium and PEMS

1 year ago

- Site selection begins – LA Region
- Organizational work begins
- Systems management concepts grow in popularity
- Generic Concept of Operations

Last six months

- I-210 Selected as candidate pilot site
- Nick Compin is now “Connected Corridors Manager”
- D7/LA Metro assign resources
- Web site launched
- Integration with MAP-21 and SHRP2
Integration

Institutional Integration

Coordination to collaboration between various agencies and jurisdictions that transcends institutional boundaries.

Operational Integration

Multi-agency and cross-network operational strategies to manage the total capacity and demand of the corridor.

Technical Integration

Sharing and distribution of information, and system operations and control functions to support the immediate analysis and response.
Institutional Integration

Caltrans District Office

County / Cities
Caltrans Operations
Transit Agencies
Planning Organizations
Emergency Responders

Support
Caltrans HQ Operations
Caltrans HQ Planning
Caltrans HQ DRI
UC Berkeley PATH
Vendors / Consulting Firms
Institutional Integration
Operational Integration

Integrated Corridor Management

- Freeway Management
- Arterial Management
- Transit Management
- Parking Management
- Information Management
Architectural Integration

Controls
- Ramps
- Signals
- Messages

Decisions
- Cities with TMC
- Cities without TMC

Caltrans District TMC with enhanced decision support

Data
- Fixed Sensors
- Probe Data
- Experience

Manual & automated
Technologies

- **Decision Support System (DSS)**
  - Provides an accurate estimate of the current state of a traffic corridor
  - Quickly performs predictions of its future performance under multiple scenarios
  - Sounds alarms of potential trouble spots
  - Evaluates different traffic management strategies, and provides the traffic manager with the most likely management strategy to improve mobility and safety on the network

- **Tools:**
  - Fast, self-calibrated, self-diagnosed and self-repairing traffic models
  - Traffic state estimation using real time heterogeneous traffic data
  - Filtering, analytics and statistical inferring techniques to predict future demands on the traffic corridor

Development of tools to analyze and design:

- Major traffic corridor operational improvements
  - ramp metering, incident management, traveler routing and diversion, toll and commuter lane (HOT) management, arterial signaling control, demand management, pricing, etc.

- Major traffic corridor infrastructure improvements
  - Additional lanes, extend ramps capacity, HOT, etc.

Quickly estimate the benefits of such actions:

- TOPL is based on macro-simulation freeway and arterial models that
  - Are easily assembled
  - Self-calibrated and self-diagnosed using traffic data,
  - Run much faster than real time
Development of tools to analyze and design:

- **Major traffic corridor operational improvements:**
  - ramp metering; incident management; traveler routing and diversion; toll and commuter lane (HOT) management; arterial signaling control; demand management; pricing; etc.

- **Major traffic corridor infrastructure improvements:**
  - Additional lanes, extend ramps capacity, HOT, etc.

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- **TOPL is based on macro-simulation freeway and arterial models that**
  - are easily assembled,
  - self-calibrated and self-diagnosed using traffic data,
  - run much faster than real time.
Mobile Millennium, TO1/TO2: hybrid data

TO 1: Pilot Procurement of Probe Data

**Purpose:** How to purchase traffic data from vendors?

**Scope of Work**
- Assessment of current practices
- Traffic data purchase (RFI and RFP)
- Vendor data fusion and validation

TO2: Objectives and Methods for Using Probe Data

**Purpose:** Determine why Caltrans should purchase traffic data from vendors

**Scope of work:**
- Assessment of current practices
- Data quality standards
- Data fusion methods
- Business analysis for buying traffic data
Next Gen Model

Collection (Multiple sources – Various data)

Fusion

Fixed Sensors

Truck Fleets

Taxies

Cell phones

PNDs

Planning - PM

Traffic Operation

Speed Information
I-210 “ICM California” Pilot Site

- Site description
- Organizational Members
- Current progress
Important Notes

I-210 selection not official, as cities have not yet agreed!

No external announcement yet

However, current partners believe there is a good chance of cities and county participation, assuming a balanced, corridor-wide approach is taken.
Selected Corridor

**Extent of Study Area**

**Managed Freeway**

**Supporting Arterials**
## Corridor Pros and Cons

<table>
<thead>
<tr>
<th>Item</th>
<th>Rating</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry</td>
<td>Excellent</td>
<td>Several Parallel arterials in close proximity of I-201; freeway frontage streets in Pasadena</td>
</tr>
<tr>
<td>Jurisdictional Environment</td>
<td>Good</td>
<td>Possibility of doing pilot deployment within one or two cities</td>
</tr>
<tr>
<td>Freeway Traffic Detection</td>
<td>Very Good</td>
<td>Sensors on mainline and most ramps</td>
</tr>
<tr>
<td>Arterial Traffic Detection</td>
<td>Promising</td>
<td>Many intersections already equipped with traffic sensors</td>
</tr>
<tr>
<td>Traffic Demand Patterns</td>
<td>Very Good</td>
<td>Westbound traffic during AM peak; eastbound traffic during PM peak, average % of trucks</td>
</tr>
<tr>
<td>Existing Freeway Control</td>
<td>Excellent</td>
<td>Existing HOV lanes; ramps and freeway interchanges metered</td>
</tr>
<tr>
<td>Existing Arterial Control</td>
<td>Good</td>
<td>Traffic responsive system already in place on some arterials, participation of key cities in IEN.</td>
</tr>
<tr>
<td>Existing Transit Services</td>
<td>Very Good</td>
<td>Metro Gold Line running parallel to I-210, in close proximity</td>
</tr>
<tr>
<td>Park-and-ride capabilities</td>
<td>Uncertain</td>
<td>Many facilities exhibit high occupancy rates</td>
</tr>
<tr>
<td>ICM Opportunities – Peak Hour</td>
<td>Challenging</td>
<td>High congestion level on freeway; some arterials with limited extra capacities at some intersections; incident response needs; different traffic pattern on Fridays</td>
</tr>
<tr>
<td>ICM Opportunities – Off Peak</td>
<td>Excellent</td>
<td>Many large scale events; incident response needs</td>
</tr>
</tbody>
</table>
ICM is Needed

- Corridor with
  - significant congestion
  - Significant number of incidents and events (Rose Bowl)
  - Significant daily (Friday weekend traffic) and seasonal (Holidays) traffic pattern variability

3820 accidents 2009-2012
7.1 accidents/mile/month
6.75 major incidents (2+ hrs)/year

2603 accidents 2009-2012
5.5 accidents/mile/month
5.25 major incidents (2+ hrs)/year
## Anticipated Timeline

<table>
<thead>
<tr>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
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<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

- **Feasibility/Concept Exploration**
- **System Requirements**
- **Detailed Design**
- **High Level Design**
- **Concept of Operation**
- **Software/Hardware Development**
- **Field Installation**
- **Testing and Verification**
- **System Deployment**
- **Operation, and Performance Analysis**
Organizational Members

- **Core Organizational Members**
  - Caltrans D7 – Project Leader assigned and provided with resources
  - LA Metro – Assigned resources
  - LA County, Department of Public Works – Discussions started
  - Cities of Pasadena, Arcadia and Monrovia (possibly others) – Contact in September
  - Metrolink – Contact to be planned
  - Southern California Association of Governments – Contact to be planned

- **Organizational Support Members**
  - Caltrans HQ, Division of Traffic Operations - Resources assigned
  - UC Berkeley/PATH – Resources assigned
  - System Metrics Group – Resources assigned
  - SANDAG – In discussion
  - USDOT – In discussion
Working Committees

- **Existing committees**
  - Outreach and Communication (*D7 Lead*)
  - Performance Metrics (*D7 Lead*)
  - Data Needs (*PATH Lead*)

- **Future Committees**
  - To be determined based on project needs

Teams with Active participation from:
- Caltrans D7
- Caltrans HQ
- LA Metro
- UCB PATH
Outreach and Communications Subcommittee

- Drafting a Fact Sheet and Speaking Points for meetings with cities
  - Important to outline benefits to the cities

- Outreach Goals
  - Educate and inform (internal partners; all levels of stakeholders, travelers)
  - Engage stakeholders
  - Implement ongoing communication strategies
  - Reach consensus on key corridor issues and strategies
  - Provide public relations component (announce project, partners, stakeholders)

- Meetings with corridor cities to start in September

- Goal: Public announcement at ITS CA Oct 1st
Performance Subcommittee

- Define performance metrics for effort
- Define performance goals
- Define evaluation methods
- Define data requirements for measuring and validating metrics
- Define level of Maturity Capability Matrix to be used
- Ensure effective use of System Engineering processes
Data Needs Subcommittee

- **Identification of data needs for**
  - Corridor operational evaluation
  - Simulation modeling of corridor
  - Feasibility of potential traffic/demand management strategies

- **Current data collection/analysis efforts**
  - Traffic flow data
  - Safety data
  - Transit operations data
  - Parking occupancy data
  - Inventory of traffic management assets (CMS, CCTV, HAR, signal controllers, etc.)
Summary

- Initial efforts going well
- Caltrans assuming responsibility for corridor wide transportation management
- Integration with Federal and State efforts proceeding
- Caltrans capable of world leadership in active traffic management
- However, still early days
- Your support and understanding is needed to ensure success
Thank you....

Questions?

Thoughts?
Tools for Operations Planning (TOPL)

Traffic model self-calibration, fault detection and repair example:

- Evaluation of coordinated ramp-metering and VSL with queue limits:

  NO RAMP METERING

  RAMP METERING:

  Current ramp storage limits
  Delay Reduction: 15.3%
**Accident management evaluation**

- **ALINEA with queue control:** upstream of accident
- **VSL control:** 3.5 miles upstream of accident, 30-55 mph
- **CMS Detour:** 10% use Carlson and Central junctions to I-580E

**Accident from 6.35 to 6.50 AM:** 2 lanes blocked

- **Delay:**
  - Worst case: 65 vh per 5 min
  - Best case: 36 vh per 5 min

**Freeway route**

**Carlson detour**

**Central detour**

No control
Functional Development Areas

- Steering Committee
  - Funding
  - Project Mgmt
  - Resources
  - Implementation
    - Input Data Processing
    - Decision Support
    - System Interfaces
    - Subsystems
  - Quality Assurance
    - Metrics
    - Validation
    - Testing
  - New Technologies
    - New Simulation Models
    - Data Sources
    - Data Fusion
    - Improved Decision Support
  - Operations
    - Deployment
    - Support
    - Daily Operation
    - Traveler Info
    - Traveler Navigation
    - Active Demand Mgmt
  - Demand Mgmt
- Outreach
  - Policy
    - Stakeholder meetings
    - MOU/Legal
  - Public Meetings
  - Education
  - Communication
  - Concept of Operations
  - Systems Requirements
  - Validation and Test Plans
  - Other Technical Documents
- Systems Eng
  - Analysis
  - Modelling
  - Simulation
- Organizational Eng
  - Training
    - Job Descriptions
  - Systems
    - Data
    - Mgmt Consulting
- Partner Mgmt
Related Efforts

- Event Mgmt System
  - DCCM
- SHRP II
- Capability Model
- MAP21
- Caltrans D7
- USDOT
- CHP Incident Mgmt

- Regional Arterial Performance
  - 511
- ICM Efforts
- Smart Corridors
- ICM Efforts
- ACCMA (I-80)
- VDOT (I-95)
- SANDAG (I-15)
- DART (US-75)
Next Steps

- **Outreach Plan**
  - Additional funding for sensing and control will be needed
  - Integration with TMC/Manual Control
  - Plans for validation and

- **Plan for LA County, Pasadena, Arcadia, Monrovia, Duarte, Irwindale, Azusa, Glendora and San Dimas involvement**
  - Cities are critical partners in the ICM effort
  - Review draft outreach and communication plan

- **Sensing and management asset needs**
  - Complete inventory of corridor control elements
  - Agree on management strategies
  - Determine if additional assets are needed
  - Locate funds and procure/install additional assets

- **Goal: Public announcement at ITS CA Oct 1st.**
## TO 1: Pilot Procurement of Probe Data

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<thead>
<tr>
<th>Task</th>
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<tbody>
<tr>
<td>1. Project Management, Coordination and Outreach</td>
</tr>
<tr>
<td>3. Site Selection and Assessment</td>
</tr>
<tr>
<td>4. Development of Technical Specification</td>
</tr>
<tr>
<td>5. Request for Proposal (RFP) Solicitation and Evaluation</td>
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<tr>
<td>6. Contract Management and Data Procurement</td>
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<tr>
<td>7. Data Collection Rollout</td>
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<tr>
<td>8. Test Fusion Schemas</td>
</tr>
<tr>
<td>9. Data Validation</td>
</tr>
<tr>
<td>10. Research on hybridization of Multiple Data Sources in Traffic Management Systems</td>
</tr>
<tr>
<td>11. Final Report</td>
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</tbody>
</table>
## TO 2: Objectives and Methods for Using Probe Data

<table>
<thead>
<tr>
<th>Work Packages</th>
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<tbody>
<tr>
<td>1. Determine data quality metrics and measurement procedures</td>
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<tr>
<td>2. Probe Data Quality Study</td>
<td></td>
</tr>
<tr>
<td>3. Data Fusion Implementation and Procedures</td>
<td></td>
</tr>
<tr>
<td>4. Sensitivity Analysis of Loop Detector Spacing and Location</td>
<td></td>
</tr>
<tr>
<td>5. Hybrid Data Roadmap</td>
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