IBM Research Smarter Transportation Analytics
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**INSTRUMENTED**
We now have the ability to measure, sense and see the exact condition of practically everything.

**INTERCONNECTED**
People, systems and objects can communicate and interact with each other.

**INTELLIGENT**
We can respond to changes quickly and accurately, and get better results by predicting and optimizing for future events.
IBM Smarter Transportation Focus Areas

- Transportation Strategy and Planning
- Transportation Maturity Model
- Total Cost of Ownership Models
- Multi-Domain Impact Analysis

Integrated Fare Management
- Integrated payment solutions for multiple transportation modes
- Shared Back office across multiple cities
- Cloud Infrastructure

Transportation Advisory Services

Innovative Transportation Pricing
- Single Highway/Bridge Tolling
- Network of Tolled Highway (incl. HOT networks)
- City Congestion Charging
- Usage Based Pricing/Taxation

Transportation Information Management
- Real Time Multimodal Traveler Information
- Performance Management and Reporting
- Traffic Prediction and Analytics
- Asset Management
- Decision Support Systems
- Multimodal Integration and Operations Optimization
# Multimodal Transportation Maturity Model

## Benchmarking

### Key:
- Singapore
- London
- Seoul
- Stockholm
- San Diego
- Other

### Strategic Planning

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silo</td>
<td>Centralized</td>
<td>Partially Integrated</td>
<td>Multimodal Integrated</td>
<td>Multimodal Optimized</td>
</tr>
</tbody>
</table>

#### Planning
- Functional Area Planning (single mode)
- Project-based Planning (single mode)
- Integrated area-wide planning (single mode)
- Integrated regional multimodal planning

#### Performance Measurement
- Minimal
- Defined metrics by mode
- Shared multimodal system-wide metrics
- Continuous system-wide performance measurement

#### Customer Management
- Minimal capability, no customer accounts
- Customer accounts managed separately for each system/mode
- Multi-channel account interaction per mode
- Integrated multimodal incentives to optimize multimodal use

#### Data Collection
- Limited or Manual Input
- System-wide real-time input
- Real-time coverage for major corridors, all significant modes
- System-wide real-time data collection across all modes

#### Data Integration
- Limited
- Integrated
- 2-way system integration
- Extended integration

#### Analytics
- Ad-hoc analysis
- Pre-planned analysis
- Detailed analysis in real-time
- Multi-modal analysis in real-time

#### Payment Methods
- Manual Cash Collection
- Automatic Cash Machines
- Electronic Payments
- Multimodal integration

#### Network Ops. Response
- Ad-Hoc, Single Mode
- Centralized, Single Mode
- Automated, Single Mode
- Multimodal Real-time Optimized

#### Incident Management
- Manual collection, respond and recovery
- Automated pre-planned multimodal recovery plans
- Dynamic multimodal recovery plans based on real-time data

#### Demand Management
- Individual static measures
- Coordinated measures with short-term adaptability
- Dynamic pricing
- Multimodal dynamic pricing

#### Traveler Information
- Static Information
- Dynamic information
- Location-based, on-journey multimodal information
- Location-based, multimodal proactive re-routing

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*Multimodal Network Management Maturity Model version 1.1*
Innovation Concepts – Transport Information Management

**Issue: strained infrastructure**
More transport capacity is needed, but construction of new physical infrastructure is **cost prohibitive**, if even possible.

**Issue: navigating mass transit**
Transit is part of the solution, but it **must be easier** for travelers to find their way and weigh options.

**Required Innovation: foundation of data integration & analytics**
- Multiple data sources across transport modes
- Integrated to single **foundation of information**
- Leveraged for **multiple uses**
- Based on **open standards**
- Integrated **systems approach**, not point solutions

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Data Integration & Analytics

Data Analytics:
- Traffic Prediction Tool
- Data Expansion Algorithm
- Bus Arrival Prediction
- Decision Support System Optimizer

Traveler Advice
- real-time advice
- route planning
- personalization

Network Response
- signal timing
- transit routing
- incident response
- performance measurement
Building the Foundation for Smarter Transportation

1. Manage Data
   - Integrate assets and information to improve operations
     - What data is relevant?
     - How can it be acquired, cleansed, and integrated?
   - Analyze Patterns
     - Customer loyalty
     - Sales and profit
     - Network awareness
   - Identify impact of changes to customer experience & operations
     - Describe the current state
     - Predict future states
     - Prescribe optimal actions

2. Optimize Outcomes
   - Predict issues across transportation modes to optimize capacity
     - How to implement actions?
     - How to disseminate information?
     - Customer satisfaction
     - Incident prevention
     - Reduced network congestion

Enabled by the IBM Government Industry Framework
Traffic Prediction Tool (TPT)

**Issue:** “real-time” is too late

Little automated use is made of the gigabytes of real-time traffic data today; often, by the time it is received, it is no longer representative of the actual traffic.

**IBM Innovation:** forecast the future

IBM’s TPT provides a layer of intelligence by using sensor data in sophisticated algorithms that create relevant insights from the raw data.

Areas of Potential Use

Traffic Operations: Advanced Traveler Information; traffic signal timing, ramp metering, route planning & advice, dynamic pricing.
5 minute-ahead volume forecast (blue) vs. actual on Dec 10, 2006.
Roadworks were present on Link 103072372 and a vehicle breakdown on Link 103064655.
NJTA TPT Test
Section of Expressway Studied

- Garden State Parkway
  - Raritan Toll Plaza to Exit 145/I-280
  - Southbound
  - Comprising 30 links on the Parkway

- New Jersey Turnpike - I-95
  - Northbound and Southbound
  - Comprising 65 links on the Turnpike

- Deployment underway following successful tests

Garden State Parkway, 10-mn predictions, daily average by road link
Overall average accuracy over two days analyzed is 95%
Traffic Prediction value proposition

- **Input to Traffic Management**
  - Visualise predicted traffic status
  - Calculate journey times

- **Traffic Prediction Tool**
  - Adjust traffic control to optimise traffic flow
  - Dynamically change road pricing
  - Adjust traffic control to prioritise public transit
  - Inform individual (e.g., travellers portal)
  - Input to journey / route estimation (e.g., SatNav)
  - Set Variable Message Signs
  - Predict bus arrival times at stops
  - Optimise bus dispatching
  - …..

- **Reduced congestion**
  - Enhanced driver satisfaction
  - Reduced environmental impact
  - Economic efficiency benefits
  - Enhanced traveller satisfaction
  - Greater use of public transport
IBM DATA EXPANSION ALGORITHM (DEA)

Current state of LTA traffic volume data

- Problem description: Determine real-time traffic when sensor data is unavailable
- Solution: IBM’s Data Expansion Algorithm (DEA)
- Outcome and Benefits: Expand real-time data to as close as possible to full network
BUS ARRIVAL PREDICTION (BAP)

Problem description:
- Provide travellers with accurate and frequently updated future bus arrival time.
- Existing similar systems’ performance failed to match the sophistication level of data source.
- Innovative approach is needed to fully unleash the useful information hidden in various data source in a more sophisticated manner, in order to bring the forecasting accuracy up to a level near plus/minus 1 minute with 90% confidence. (*Current service level is within +/- 3 min with 85% confidence)

Solution:
- IBM is currently collaborating with LTA, co-developing a new forecasting algorithm.
- It is mining periodic trends and patterns of bus arrivals, using bus GPS data
- as well as the TPT prediction of future traffic status on subsequent links along the bus routes.

Outcome (**ongoing work, interim outcome**):
- Selected bus service route 61 and 75, 8 bus stops each.
Decision Support System (DSS) Optimizer

- Transportation Command Centers today are largely not equipped to determine response plans based upon large volumes of data and analytic methods.

- Typically, today, some real-time data is visualized, but the expected outcomes of potential responses are generally not computed.

- It is widely accepted that the “Command Center of the Future” should leverage the massive amounts of transport data for more effective response plan generation.

- This is the motivation of the Decision Support System (DSS) Optimizer
Decision Support System Optimizer
Without DSS Optimizer
Decision Support System Optimizer
With DSS Optimizer

1) VMS Route Guidance
2) Ramp Closures
3) Optimized signal & ramp metering

<table>
<thead>
<tr>
<th>Response Plan</th>
<th>Deploy Time</th>
<th>Release Time</th>
<th>Expected benefit</th>
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<tbody>
<tr>
<td>1, 2 and 3</td>
<td>Immediate</td>
<td>T + 30 min</td>
<td>Highest</td>
</tr>
<tr>
<td>1 and 3 only</td>
<td>Immediate</td>
<td>T + 20 min</td>
<td>Moderate</td>
</tr>
<tr>
<td>2 only</td>
<td>T + 5 min</td>
<td>T + 45 min</td>
<td>Moderate</td>
</tr>
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