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 in entirely new ways.

**INTELLIGENT**
We can respond to changes quickly and accurately, and get better results by predicting and optimizing for future events.
The commuter pain index

- Surveyed 8,042 commuters in 20 cities on six continents to better understand consumer attitude toward traffic congestion.

- Compiled the results into an Index that ranks the emotional and economic toll of commuting in 20 international cities (on a scale of 1 to 100, with 100 being the most onerous).

- The index is comprised of 10 issues:
  - commuting time
  - time stuck in traffic
  - price of gas is already too high
  - traffic has gotten worse
  - start-stop traffic is a problem
  - driving causes stress
  - driving causes anger
  - traffic affects work
  - traffic so bad driving stopped
  - decided not to make trip due to traffic

In order to improve traffic flow and congestion, cities need to move beyond knowing and reacting; they have to find ways to anticipate and avoid situations that cause congestion that could turn the world into one giant parking lot.
IBM Smarter Transportation Focus Areas

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

Transportation Advisory Services

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

Integrated Fare Management

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

Innovative Transportation Pricing

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

Transportation Information Management
# Multimodal Transportation Maturity Model

## Benchmarking

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**Singapore**
**London**
**Stockholm**
**San Diego**
**Seoul**
**Other**
# Multimodal Transportation Maturity Model

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### Notes:
- **strategic planning**
- **real-time information creation capability**
- **real-time intervention capability**
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### Strategic Planning
- **Planning**
  - Functional Area Planning (single mode)
  - Project-based Planning (single mode)
  - Integrated area-wide planning (single mode)
  - Integrated corridor and multimodal planning
  - Integrated regional multimodal planning

### Performance Measurement
- **Performance Measurement**
  - Minimal
  - Defined metrics by mode
  - Limited integration across organizational units
  - Shared multimodal system-wide metrics
  - Continuous system-wide performance measurement

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

### Data Collection
- **Data Collection**
  - Limited or Manual Input
  - Near real-time for major routes
  - Real-time for major routes using multiple inputs
  - Real-time coverage for major corridors, all significant modes
  - System-wide real-time data collection across all modes

### Data Integration
- **Data Integration**
  - Limited
  - Networked
  - Common user interface
  - 2-way system integration
  - Extended integration

### Analytics
- **Analytics**
  - Ad-hoc analysis
  - Per-user Systematic analysis
  - High-level analysis in near real-time
  - Detailed analysis in real-time
  - Multi-modal analysis in real-time

### Payment Methods
- **Payment Methods**
  - Manual Cash Collection
  - Automatic Cash Collection
  - Electronic Payments
  - Multimodal integration
  - Multimodal, multi-media (fare cards, cell phones, etc)

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

### Incident Management
- **Incident Management**
  - Manual detection, response and recovery
  - Manual detection, coordinated response, manual recovery
  - Automatic detection, coordinated response and manual recovery
  - Automated pre-planned multimodal recovery plans
  - Dynamic multimodal recovery plans based on real-time data

### Demand Management
- **Demand Management**
  - Individual static measures
  - Individual measures with long term variability
  - Coordinated measures, with short term variability
  - Dynamic pricing
  - Multimodal dynamic pricing

### Traveler Information
- **Traveler Information**
  - Static Information
  - Static trip planning with limited real-time inputs
  - Multi-channel trip planning and account-based alert subscription
  - Location-based, on-journey multimodal information
  - Location-based, multimodal proactive re-routing
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**Real-time Information Creation Capability**

- San Diego
- London
- Stockholm
- Singapore
- Seoul
- Other
# Multimodal Transportation Maturity Model

## Benchmarking

### Level 1: Silo
- **Planning**: Functional Area Planning (single mode)
- **Performance Measurement**: Minimal
- **Customer Management**: Minimal capability, no customer accounts
- **Data Collection**: Limited or Manual Input
- **Data Integration**: Limited
- **Analytics**: Ad-hoc analysis
- **Payment Methods**: Manual Cash Collection
- **Network Ops. Response**: Ad-Hoc, Single Mode
- **Incident Management**: Manual detection, response and recovery
- **Demand Management**: Individual static measures
- **Traveler Information**: Static Information

### Level 2: Centralized
- **Planning**: Project-based Planning (single mode)
- **Performance Measurement**: Defined methods by mode
- **Customer Management**: Customer accounts managed separately for each system/mode
- **Data Collection**: No real-time data collection
- **Data Integration**: Limited integration
- **Analytics**: Detailed analysis in real-time
- **Payment Methods**: Electronic Payments
- **Network Ops. Response**: Coordinated, Single Mode
- **Incident Management**: Manual detection, coordinated response and recovery
- **Demand Management**: Integrated, short term
- **Traveler Information**: Static Information

### Level 3: Partially Integrated
- **Planning**: Integrated area-wide planning (multi-mode)
- **Performance Measurement**: Defined system-wide metrics
- **Customer Management**: Multi-channel account interaction per mode
- **Data Collection**: Real-time coverage of major corridors, all significant modes
- **Data Integration**: X-way system integration
- **Analytics**: Multi-modal analysis in real-time
- **Payment Methods**: Multimodal, multimedia (fare cards, cell phones, etc)
- **Network Ops. Response**: Integrated, Multi-modal
- **Incident Management**: Automated pre-planned multimodal recovery plans
- **Demand Management**: Dynamic pricing
- **Traveler Information**: Location-based, on-journey multimodal information

### Level 4: Multimodal Integrated
- **Planning**: Integrated regional multimodal planning
- **Performance Measurement**: Continuous system-wide performance measurement
- **Customer Management**: Integrated multimodal incentives to optimize multimodal use
- **Data Collection**: System-wide real-time data collection across all modes
- **Data Integration**: Extended integration
- **Analytics**: Multi-modal analysis in real-time
- **Payment Methods**: Multimodal, multimedia (fare cards, cell phones, etc)
- **Network Ops. Response**: Multimodal Real-time Optimized
- **Incident Management**: Dynamic multimodal recovery plans based on real-time data
- **Demand Management**: Multimodal dynamic pricing
- **Traveler Information**: Location-based, multimodal proactive re-routing

### Level 5: Multimodal Optimized
- **Planning**: Integrated regional multimodal planning
- **Performance Measurement**: Continuous system-wide performance measurement
- **Customer Management**: Integrated multimodal incentives to optimize multimodal use
- **Data Collection**: System-wide real-time data collection across all modes
- **Data Integration**: Extended integration
- **Analytics**: Multi-modal analysis in real-time
- **Payment Methods**: Multimodal, multimedia (fare cards, cell phones, etc)
- **Network Ops. Response**: Multimodal Real-time Optimized
- **Incident Management**: Dynamic multimodal recovery plans based on real-time data
- **Demand Management**: Multimodal dynamic pricing
- **Traveler Information**: Location-based, multimodal proactive re-routing

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**Note**: The diagram illustrates the progression from Level 1 to Level 5, highlighting key improvements in strategic planning, real-time information creation capability, and real-time intervention capability.
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

Traveler Advice
- Real-time advice
- Route planning
- Personalization

Network Response
- Signal timing
- Transit routing
- Incident response
- Performance measurement

Data Analytics:
- Traffic Prediction Tool
- Data Expansion Algorithm
- Bus Arrival Prediction
- Decision Support System Optimizer
Building the Foundation for Smarter Transportation

1 Manage Data
- Management efficiency
- Return on assets

2 Analyze Patterns
- Customer loyalty
- Sales and profit
- Network awareness

3 Optimize Outcomes
- Customer satisfaction
- Incident prevention
- Reduced network congestion

Integrate assets and information to improve operations
What data is relevant? How can it be acquired, cleansed, and integrated?

Identify impact of changes to customer experience & operations
Describe the current state, predict future states, prescribe optimal actions.

Predict issues across transportation modes to optimize capacity

Enabled by the IBM Government Industry Framework
Use of Smarter Planet capabilities

© 2011 IBM Corporation
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.

Tool screenshot

TPT accurately forecasts future traffic conditions.
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
  - Calculate journey times
  - Visualise predicted traffic status
  - 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

- Traffic Prediction Tool
  - Greater use of public transport
  - Enhanced traveller satisfaction
  - Reduced environmental impact
  - Economic efficiency benefits
  - Enhanced driver satisfaction
  - Reduced congestion
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
Without DSSO

Late!
Early!
Off Route
Malfunction
ALARM!
Request To Talk
HELP!
What is the nearest replacement bus?
Do we have extra drivers?
Has there been an accident?
What is causing these problems?
What are the impacts to later service?
How can I fix each problem?
How important is this problem?
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>
</tr>
</thead>
<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>
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</tbody>
</table>
Screen Shot of DSSO

- Includes traffic prediction, useful for normal or semi-normal conditions
- Incident detection module is present.
- Includes Incident Impact Factor Evaluation, a link-by-link list of impacted links and the degree of impact.
- DSSO Optimal control plan generation.
- Expected benefit and risk of each DSSO-generated plan
- Ability to enter a different, non-DSSO generated plan and assess its expected benefit.