FUTURe city – Seminar series 2017 2018

Big Data Analytics For Connected Vehicles And Smart Cities

Bob McQueen, CEO, Bob McQueen and Associates
Instructional Objectives

1. Define a smart city
2. Identify importance of transportation in a smart city
3. Define the role of connected and autonomous vehicles in the smart city
4. Define Big Data
5. Define big data analytics and relevance to transportation
6. Explain the value of Use Cases
7. Discuss Smart Data Management
8. Define an effective approach to Smart Data Management
9. Discuss a planning approach to smart cities
10. Define a benefit and cost approach
Topics

- What is a smart city?
- The importance of transportation in a smart city
- What is Big data?
- What are big data analytics?
- The value of big data analytics in transportation
- Getting what you want from big data analytics: Use Cases
- Smart Data Management and how to get there
- Planning approach to smart cities
- Benefit and cost approach
- Summary of instructional objectives
What is a Smart City?

• Wider than transportation
• Disproportionate importance of transportation
• A range of transportation services
• Connectivity
• Alignment between modes
• Optimization of transportation services
• Matching supply and demand through variations over time
• Monitoring, managing, and learning
What is a Smart City?

- Energy
- Smart Buildings
- Smart healthcare
- Smart education
- Smart retail
- Utilities
- Manufacturing
- Urban Agriculture
- Transportation

Importance of Transportation in Smart Cities

- Energy: 28% of US energy used for transportation
- Smart Buildings to live and work: accessibility
- Smart healthcare: accessibility
- Smart education: accessibility
- Smart retail: accessibility
- Manufacturing: accessibility
- Utilities: EV charging, sensor sharing
- Urban Agriculture: farm to table chain
- Transportation: mobility, accessibility, safety, efficiency, user experience

CPAI-I_001-v2_Anatomy.pdf

http://www.cptf.cityprotocol.org/CPAI/CPA-I_001-v2_Anatomy.pdf
Importance of Transportation in Smart Cities

**Smart:**
- Connected and autonomous vehicles
- Fee payment
- Sensors
  - Infrastructure
  - Probes
- Communications
  - Fiber
  - Wireless V to X
- Transportation management
  - Traffic signals
  - Freeway
  - Transit
  - Freight
  - non-motorized
- Traveler information
Transportation as a Single System

• What is a system?
  • It has clarity of purpose
  • It is connected together
  • We can find out its status at any given time
  • It can adapt to changes in the environment

• “Single system” also includes alignment between planning, design, project delivery, operations, and maintenance

Connected and Autonomous Vehicles

• The Internet of Things

• Cities will roll out more autonomous vehicles over the next five years, including First mile last mile shuttles

• Electric vehicles will outnumber gas powered cars in the next 15 years

• Crowdsourced ride-sharing services will go global (Mobility as a Service)

• Vehicles will connect to transportation systems, Ford says it will equip 20 million cars with built-in modems over five years

• City managers will have new operating systems to manage transportation, data will be integrated from multiple endpoints.
Automobile Electronics and Information Technology

• Today: 30 to 35% of car costs is comprised of automotive electronics
• 2030: this will grow to 50%

<table>
<thead>
<tr>
<th>Automotive electronics</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active safety</td>
<td>Avoid and mitigate the effects of a crash</td>
</tr>
<tr>
<td>Chassis electronics</td>
<td>Monitor and manage the chassis</td>
</tr>
<tr>
<td>Driver assistance</td>
<td>Decision support for the driver</td>
</tr>
<tr>
<td>Engine electronics</td>
<td>Monitor and manage engine operation</td>
</tr>
<tr>
<td>Entertainment systems</td>
<td>In car entertainment systems such as radio and digital music players</td>
</tr>
<tr>
<td>Passenger comfort</td>
<td>The air conditioning, heated seats and other applications to increase passenger comfort</td>
</tr>
<tr>
<td>Transmission electronics</td>
<td>Monitor and manage the operation of the transmission between the engine and the wheels</td>
</tr>
</tbody>
</table>
Connected Vehicles

Wide-area wireless

- Two different approaches
  - 5G and beyond
    - Wide area or link focus
  - DSRC
    - Intersection focus

Dedicated Short Range Communications (DSRC)
Connected Vehicle Services for a Smart City

DSRC

V2I Safety
- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety
- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assistant (LTA)
- Blind SpotLane Change Warning
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

Agency Data
- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

Environment
- Eco-Approach and Departure at Signalized Intersections
- Eco-Speed Signal Timing
- Eco-Traffic Signal Priority
- Connected EcoDriving
- Wireless Infrastructure/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

Road Weather
- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WRIINFO)

Mobility
- Advanced Traveler Information System
- Intelligent Traffic Signal System (ITSIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PEGSIG)
- Emergency Vehicle Preemption (PREEMP)
- Dynamic Speed Harmonization (SDHARM)
- Queue Warning (QWARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (IWC-ZONE)
- Emergency Communications and Evacuation (ECEC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (TDISP)
- Dynamic Roadserving (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

Wide-area wireless

On-the-road diagnostics
- Reduced warranty cost 50 percent per repair.
- Reduced diagnostic time 70 percent per repair.
- Increased customer uptime by 10 percent per repair.

Campaign reduction
- Reduced disruption of customer operations by 25 percent.
- Reduced warranty cost of the software update by 25 percent.

Predictive maintenance
- Address critical repairs before failure occurs.
- Increased uptime by 30 percent.
- Accelerated root-cause analysis by 25 percent.

Watch the video.

Location-based services: what’s analytics’ role?

Most of us are familiar with graphs and reports that show trends, ratios and rankings, such as line charts, pie charts and Pareto charts. While this information is useful in telling us what happened, it falls short of telling us why it happened. And if you don’t know why something happened, you haven’t a clue of what might happen next. So you are left to use intuition, deductive reasoning and past experiences - aka your gut - to make decisions about the future.

Analytics will bridge that gap. It reveals correlations and causations. It uses sophisticated math and statistics to accurately forecast and predict what is most likely to happen. And it allows you to interject your domain knowledge to assess unprecedented what-if scenarios.

In short, analytics lets you visualize location data to provide insights that improve all aspects of your business.
Connected versus Autonomous Vehicles

• Connected: two-way communications from vehicle to infrastructure and vehicle to vehicle

• Autonomous: driverless operation

• An Autonomous Vehicle is one that is capable of operation without a driver
  • First mile, last mile shuttles
  • Cars
  • Trucks
  • Buses
Autonomous Shuttle

- Easymile shuttle
- 12 person capacity
- Used as driverless bus in Taipei August 2017
- Being deployed in California at GoMentum Station
- Demo in Jacksonville
Autonomous Trucks

• Intertraffic 2016
• European truck platooning challenge
• Rotterdam, Frankfurt and Vienna
• Two or more trucks traveling in convoy in close proximity
• Also Otto self driving trucks on Interstates in the USA (owned by Uber)
Big Data Aspects

- 2013 Ford Fusion Energi Hybrid
  - 145 actuators
  - 4716 signals
  - 74 sensors
  - More than 70 onboard computers
  - 25 GB of data per hour
  - 2 ZB of data every year nationally

- Tidal wave of data
- Will we get access to it?
- Do we need it all?
What is Big Data?

- Type
- Volume
- Velocity
- Variety
- Variability
- Complexity
- Veracity

**New**
- Analytics: graph and path analytics, and analytics on **new, non-relational data types** (coupled with existing relational data)
- Tools: uncover insights from data such as text in accident reports, or patterns in visuals, to quickly **find the signal in the noise**
- Economics: retain, do not throw away signal timings, speed, flow and occupancy data, by **leveraging “hot and cold data” storage**
- Architecture: hybrid ecosystem that allows both old and new tools and enables rapid **discovery analytics on new data**

**Not New**
Most big data use cases are variations on:
- Safety,
- Efficiency
- User experience

...questions that public service agencies have been addressing for years
Evolution

INCREASING Data Variety and Complexity

DECREASING Value Density in the Data

BIG DATA

User Generated Content
Mobile Web
Sentiment
External Demographics

WEB

User Click Stream
Mobile Web
Dynamic Pricing
A/B Testing

CRM

Offer Details
Segmentation
Affiliate Networks
Search Marketing
Behavioral Targeting
Dynamic Funnels

ERP

Purchase Detail
ERP
Customer Touches
Support Contacts

Purchase Record
Payment Record
SMS/MMS

Exabytes

Petabytes

Terabytes

Gigabytes
Towards Automation

Data Sophistication
Continuous update and time-sensitive queries become important

OPERATIONALIZING
Applying insights to transportation operations

EVENT-BASED TRIGGERING
Automated transportation back office

ANALYZING
Mechanisms related to transportation demand and supply

PREDICTING
Future Transportation Demand and Supply

REPORTING
Historical Performance Reporting

Database Requirement: Analytic foundation must handle multidimensional growth!

Growth in Query complexity, Workload mixture, Depth of history, Number of users, Expectations

Workload Complexity
Primarily batch and some ad hoc reports
Increase in ad hoc analysis
Analytical modeling grows
Continuous update and time-sensitive queries become important
Event-based triggering takes hold

Batch
Ad Hoc
Analytics
Event-based Triggering
Continuous Update/Short Queries

Single View of Transportation – Better, Faster Decisions – Drive Safety, Efficiency, User Experience
## What are Big Data Analytics?

<table>
<thead>
<tr>
<th>Services</th>
<th>Analytics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset and maintenance management</td>
<td>Asset performance index, asset maintenance standards compliance measure, optimal intervention point analytic</td>
</tr>
<tr>
<td>Connected vehicle</td>
<td>Lane changes per mile, steering angle compared to road geometry, brake applications per mile, driving turbulence index, minutes per trip, trip time reliability index, no of stops per trip</td>
</tr>
<tr>
<td>Connected, involved citizens</td>
<td>Citizens awareness levels index, citizens satisfaction levels</td>
</tr>
<tr>
<td>Integrated electronic payment</td>
<td>Transit revenue per passenger, transit seat utilization, toll revenue per vehicle and per trip, premium customer identification index, parking revenue per slot, payment system revenue achieved compared to forecast and addressable market</td>
</tr>
<tr>
<td>Intelligent sensor-based infrastructure</td>
<td>Data quality index, transportation conditions index, trip time variability index</td>
</tr>
<tr>
<td>Low cost efficient, secure and resilient ICT</td>
<td>Network load compared to capacity index, network latency, cost of data transfer, network security index</td>
</tr>
<tr>
<td>Smart grid, roadway electrification and electric vehicle</td>
<td>Electric vehicle charging points per mile, electric vehicle charging points per head of population, number of electric vehicles as a percentage of the total fleet, electric vehicle miles per day, electric vehicle miles per trip, electric vehicle miles between charges</td>
</tr>
<tr>
<td>Smart land-use</td>
<td>Observed trip generation rates for different land uses, observed actual trips between zones, land value transportation index, zone accessibility index</td>
</tr>
<tr>
<td>Strategic business models and partnering</td>
<td>Percentage of private sector investment, number of partnerships, improvement in service delivery for each private sector dollar invested</td>
</tr>
<tr>
<td>Transportation governance</td>
<td>Transportation efficiency for each dollar spent, supply and demand matching index, transportation agency coordination index, partnership cost-saving index, cost of data storage and manipulation compared to services provided</td>
</tr>
<tr>
<td>Transportation management</td>
<td>Mobility index, citywide job accessibility index, citywide transportation efficiency index, reliability index, end-to-end time including modal interchanges index</td>
</tr>
<tr>
<td>Traveler information</td>
<td>Traveler satisfaction index, decision quality information index, behavior change index</td>
</tr>
<tr>
<td>Urban analytics</td>
<td>Number of analytics in use, value of services managed by analytics, money saved through efficiencies gained by analytics</td>
</tr>
<tr>
<td>Urban automation</td>
<td>Percentage of automated vehicles within the entire citywide fleet, percentage of automated vehicles in use by city agencies and private fleets, proportion of deliveries made by automated vehicles, proportion of passengers carried by automated transit</td>
</tr>
<tr>
<td>Urban delivery and logistics</td>
<td>Average cost of urban delivery, average time for end-to-end delivery, freight and logistics user satisfaction index, freight management satisfaction index</td>
</tr>
<tr>
<td>User focused mobility</td>
<td>Citywide mobility index, user satisfaction index, transportation service delivery reliability index</td>
</tr>
</tbody>
</table>
Getting What You Want From Big Data Analytics

- Difference between reporting and analytics
- The importance of Use Cases
- Getting started, developing a roadmap, Defining the future vision
- Building bridges
  - Between data science and transportation
  - Between departments
  - Between agencies and partners
- Using data as the “glue”
- Defining needs, issues, problems and objectives
- Reporting
  - Questions predefined
  - Focus on “knowing”
- Analytics
  - Different questions can be defined
  - Focus is on improving organizational performance by analytics applied to management
- Reporting makes you a well informed spectator
- The right analytics can make you the coach with the ability to change the performance of the team
Focus on Operations for this Lecture

• Opportunities and challenges

• Illustrating the value of analytics in operations through Use Cases

- Match supply and demand
- Explore alternatives
- Understand effects
- Develop results-driven investment programs

- Define projects
- Select technology
- Estimate cost
- Develop design concepts
- Develop detailed design

- Project management
- Project delivery
- Testing
- Commissioning
- Partnership management

- Monitor status
- Collect data
- Develop information
- Build intelligence
- Define strategies
- Implement strategies

- Develop maintenance policies
- Monitor device status
- Identify intervention points
- Assess device performance

Plan → Design → Build → Operate → Maintain

- Design
- Build
- Operate
- Maintain

- Define projects
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Why focus on operations?

- Operations as a significant data generator
  - SANDAG
    - 1 TB per day
    - Assumed 200 days per year operation
    - 200 TB per annum
  - Connected vehicle
    - 2 ZB per annum

- The impact of operations on safety, efficiency, and user experience

- Coordination of planning, design, project delivery, operations, and maintenance to deliver quality services

<table>
<thead>
<tr>
<th>Department</th>
<th>Proportion of the data originating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>20%</td>
</tr>
<tr>
<td>Design</td>
<td>10%</td>
</tr>
<tr>
<td>Project delivery</td>
<td>5%</td>
</tr>
<tr>
<td>Operations</td>
<td>50%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>15%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

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Operations Challenges

advanced agency appropriate asset awareness balancing boundaries business champion communicating conductivity coordinating defining developing different drivers entire establish funding geographic identifying implementation improving investment justification justifying local maintenance major management measure number obtaining operations organization parallel partners performance procedures processes project reducing required resources roadmap systems technologies tracking traffic transportation
## Operations Use Case Examples

<table>
<thead>
<tr>
<th>Use Case Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic anomaly detection and communications</td>
<td>1</td>
</tr>
<tr>
<td>Towing and recovery management</td>
<td>2</td>
</tr>
<tr>
<td>Results driven investment</td>
<td>3</td>
</tr>
<tr>
<td>Asset management</td>
<td>4</td>
</tr>
<tr>
<td>Transportation network management</td>
<td>5</td>
</tr>
<tr>
<td>Transportation systems management and operation impact analysis</td>
<td>6</td>
</tr>
<tr>
<td>Developer fee management</td>
<td>7</td>
</tr>
<tr>
<td>Regionwide safety analysis</td>
<td>8</td>
</tr>
<tr>
<td>Regionwide speed in bottleneck analysis</td>
<td>9</td>
</tr>
<tr>
<td>Mobility as a service</td>
<td>10</td>
</tr>
<tr>
<td>Connected citizens and travelers</td>
<td>11</td>
</tr>
<tr>
<td>Project tracking and coordination</td>
<td>12</td>
</tr>
</tbody>
</table>
## 1. Traffic anomaly detection and communications

### Objective / Problem Statement
- Bring data from multiple sources to a central data lake
- Conduct advanced analytics on the combined data source to detect anomalies
- Support the effective and efficient communication of anomalies to the appropriate parties

### Business Benefits
- Increase safety
- Increase efficiency
- Enhanced user experience

### Success Criteria
- Reduction in accidents and fatalities
- Faster response times
- Greater understanding of accident mechanisms

### Source Data
- Traffic flow
- Wrong way driver detectors
- Traffic speeds

### Expected Outcome of Analysis
- Reduction in accidents and fatalities
- Development of a better understanding of causal factors

### Challenges
- Speed of processing and communications
- Combining relevant data
- Taking appropriate action based on new insight and understanding

### Analytic Techniques
- Speed variability
- Traffic turbulence
- Wrong Way detection
- Recurring congestion identification
- Nonrecurring congestion identification
## 2. Towing and recovery management

### Objective / Problem Statement
- Improve the efficiency of towing and recovery
- Optimize the investment in towing and recovery operations
- Ensure consistent policy across the entire region

### Business Benefits
- Reduce congestion
- Improved safety
- Enhanced user experience

### Success Criteria
- Reduction in towing and recovery time
- Reduction of variability in towing and recovery time across the region
- Higher level of user satisfaction
- Optimized investment in towing and recovery capital and operations investments

### Source Data
- AVL data for towing and recovery vehicles
- Incident logs
- Courtesy patrol logs
- Traffic speeds
- Traffic flows
- Capital and operating cost of towing and recovery

### Challenges
- Access to relevant data
- Combining relevant data
- Defining appropriate analytics
- Using and communicating appropriate analytics

### Expected Outcome of Analysis
- Shorter towing and recovery times
- Less variability in towing and recovery times across the region
- Optimized investments in towing and recovery capital and operations

### Analytic Techniques
- Towing and recovery time analysis
- Towing and recovery time variability analysis
- Unit cost analysis for towing and recovery capital and operating costs
Objective / Problem Statement
- Improve expected versus actual benefits by measuring investment effectiveness.
- Investment requirements often exceed available funding, so there is need to balance funding between physical infrastructure (e.g. asphalt) and programs in intelligent transportation systems that better use available capacity.

Success Criteria
- Better targeting of funding
- Greater understanding of the effects of investments
- Better matching of investment to problem areas

Source Data
- Project costs
- Program costs
- Project effects
- Program effects

Expected Outcome of Analysis
- Better prioritization process, through analytics that define specific effects of a range of investments including intelligent transportation systems
- Adoption of a results driven approach, with focus on optimization of investments
- Understand impact of transportation investments from a detailed understanding of effects

Business Benefits
- Ability to do before vs. after investment analyses
- Isolating the effects of investments

Challenges
- Merging work program and other investment program data with transportation condition data
- Developing and agreeing suitable analytics to guide the investment program

Analytic Techniques
- Unit cost per unit affect

References
Owner: Bob McQueen

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Owner: Bob McQueen

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Analytic Techniques
- Unit cost per unit affect

References:
Owner: Bob McQueen
## 4. Asset Management

### Objective / Problem Statement
- Ensure that assets are managed as well as possible including the definition of optimal intervention points and the application of citywide standards for maintenance

### Business Benefits
- Better cost vs. performance results for asset and maintenance management
- More consistent and appropriate levels of maintenance
- Better understanding of relevant intervention points and replacement cycles

### Success Criteria
- Reduced cost of maintenance
- Higher level of maintenance
- More consistent level of maintenance
- Better understanding of the lifecycle for assets

### Source Data
- Inventory of assets
- Asset performance data
- Asset maintenance standards
- Historical expenditure on asset maintenance

### Expected Outcome of Analysis
- Accurate MTBF calculations
- Separation of routine from non-routine maintenance patterns
- Ability to include sensor data into analyses of historical and predictive maintenance
- Ability to optimize intervention points based on data and life extension programs
- More consistent application of maintenance standards that are appropriate to each device

### Challenges
- Using data to define appropriate maintenance policy based on asset performance
- Obtaining an accurate inventory of current devices
- Integrating results into current process

### Analytic Techniques
- Mean time between failures
- Routine vs. non-routine maintenance
- Asset performance index
- Optimal intervention points

### References
Owner: Bob McQueen
5. Transportation Network Management

**Objective / Problem Statement**
- Optimize transportation performance management, use of observed data and scientific techniques, development of new tools to make transportation performance management better. End goal is to improve safety, increased efficiency and provide an enhanced traveler experience.

**Business Benefits**
- Better transportation performance management, increased safety, improved efficiency and enhanced traveler experience
- Better compliance with government regulations and expectations on performance
- Ability to measure the effectiveness of performance management strategies

**Success Criteria**
- Better transportation performance management
- More insight and understanding of prevailing transportation conditions
- Development of predictions for future transportation conditions

**Source Data**
- Private sector detail data on speeds, volumes, etc
- U.S. Census data
- Transit agency data
- Local department of transportation data
- County data, city data

**Expected Outcome of Analysis**
- Use of observed data and data science to evaluate transportation performance
- Identify capacity improvement opportunities
- Reduced transportation service delivery costs

**Challenges**
- Coordinating performance management across modes
- Bringing data together from multiple sources
- Validating and verifying the data
- Agreeing the coordinated list of analytics to be used across all modes

**Analytic Techniques**
- Transportation performance Index
- Travel time variability
- Travel value proposition
- Regional congestion index
- Overall cost of travel
- Accessibility index

**References**
Owner: Bob McQueen
### Objective / Problem Statement
- Quantify the safety effects of transportation systems management and operations
- Quantify the efficiency effects of transportation systems management and operations
- Quantify the user experience effects of transportation systems management and operations

### Business Benefits
- Providing justification for investment in transportation systems management and operations equipment and staff resources
- Improved transportation systems management operations
- Increase safety
- Increase efficiency
- Enhanced user experience

### Success Criteria
- Clearly defined estimates of the effects of transportation systems management and operations

### Source Data
- Investments in transportation systems management and operations equipment and staff
- Accident data
- Operations efficiency data
- User satisfaction data

### Expected Outcome of Analysis
- Appropriate investments in transportation systems management and operations
- Improved efficiency of transportation systems management and operations
- Better service quality for transportation

### Challenges
- Access to data
- Combining the data
- Keeping the data up-to-date
- Isolating the effects of transportation systems management and operations from other factors

### Analytic Techniques
- TSM&O safety index
- TSM&O efficiency index
- TSM&O user experience index
Objective / Problem Statement
• Manage the developer fee process from end to end
• Improve the efficiency of the developer fee process

Business Benefits
• Increasing cash flow
• Increasing revenue
• More efficient distribution of developer fees
• More accurate attribution of developer fees

Success Criteria
• Improve cash flow
• Increased revenue

Source Data
• Development data
• Fee data
• Develop a database
• Financial data

Expected Outcome of Analysis
• Accelerating the delivery of developer fees
• Improving compliance with respect to developer fees
• Better management of the end-to-end process
• Improved cash flow
• Increased revenue

Challenges
• Identifying the data sources
• Bringing the data together
• Developing a process map
• Identifying performance measures
• Building the system

Analytic Techniques
• Percentage compliance
• Number of days from request to delivery of fee
• Fee revenue
## 8. Regionwide safety analysis

### Objective / Problem Statement
- Understand the behaviors, infrastructure and environmental factors, and vehicle, context and other causes of safety issues
- Identify investments that directly or indirectly increase safety and prioritize by likely value

### Business Benefits
- Reduced numbers of accidents and associated societal costs, including congestion costs
- Ability to separate the contribution of the various variables to safety issues (either accidents or even near-misses). Highway safety depends on design, traffic mix, congestion levels and many other contributing variables, including weather

### Success Criteria
- Reduced highway accidents, better understanding of highway accident causes, improvement in the use of enforcement data

### Source Data
- Rich data are available on incidents/accidents on highways, from traffic management centers and law enforcement but it resides in multiple silos and significant content is in text format
- Big data elements such as traffic conditions (from sensors on speed, flow and lane occupancy), traffic signal, weather and other data, provide significant detail on context

### Expected Outcome of Analysis
- Identifying classes of similar accidents and contributing factors
- Quantifying frequency by accident type allows prioritization by impact, striving to higher safety
- Better understanding accident causes and the effects of remedial measures

### Challenges
- Developing a methodology for multiple factor crash analysis
- Verifying the quality of law enforcement data
- Ensuring that data has same time base and Geographical referencing base

### Analytic Techniques
- Classes of accidents/patterns discerned
- Geospatial patterns by using geospatial kernel smoothing & other spatial techniques
- Sequences of events leading to accidents/incidents can be found by pathing analysis
# 9. Regionwide speed and bottleneck analysis

## Objective / Problem Statement
- Reduce delays due to congestion and improve travel time reliability
- Improve traffic flow on arterials and suburban streets, through investments in smart traffic signals and improvement of algorithms for coordination of signals

## Business Benefits
- New analytics that can help identify patterns of speed variability, bottlenecks, etc. that can be used in amelioration planning.

## Success Criteria
- More scientific approach to traffic engineering of freeways
- Better matching of investment plans to needs
- More insight and understanding into prevailing in future traffic conditions

## Source Data
- Public sector sensor/video capture of vehicle speed, flow and lane occupancy data and private sector sources of similar data
- Public sector events data, e.g. accidents, planned closures
- Reference data on roadways, lane configurations, signals
- Range of external data sources, weather, origin & destination

## Expected Outcome of Analysis
- More efficient transportation, safer, with better user experience in travel time reliability and with calmer traffic flows
- Better understanding of speed variability patterns, more detailed than previously detectable
- More precise prioritization of capacity improvements
- Analytics techniques to understand speed variability on roads, identify and characterize bottlenecks and apply scientific traffic engineering techniques

## Challenges
- Integrating private sector speed data with public sector traffic flow and other data
- Establishing a suitable agreement with the private sector data provider

## Analytic Techniques
- Presence of bottlenecks and their extent in time and length
- Speed variability patterns near bottlenecks, at back of queue
- Analytics on recurring versus nonrecurring congestion

---

References
Owner: Bob McQueen
## 10. Mobility As A Service

### Objective / Problem Statement
- Create a means to deliver information on the multi-modal services that are available, inclusive of cost, time, reliability

### Business Benefits
- Greater end-user awareness of mobility choices and the various cost, time, reliability components
- More flexible choices for mobility within an urban area including information on available options for mobility from both the public and private sectors

### Success Criteria
- More choices for travelers in the city
- Better accessibility
- Higher efficiency
- Better value proposition for all travelers

### Source Data
- Origin and destination data
- Transportation service option data including availability, cost and reliability

### Expected Outcome of Analysis
- Understanding of transportation service cost comparisons
- Analytics on cost versus user experience

### Challenges
- Establishing suitable smart phone apps
- Establishing partnerships with mobility as a service providers
- Establishing data sharing agreements
- Obtaining agreement on the parameters to be used

### Analytic Techniques
- Establishment of a mobility as a service portfolio
- Network models of multi-modal mobility
- Comparison of multi-modal trip time/cost/variability to single mode

### Analytic Techniques
- Establishment of a mobility as a service portfolio
- Network models of multi-modal mobility
- Comparison of multi-modal trip time/cost/variability to single mode
### 11. Connected, Citizens & Visitors

#### Objective / Problem Statement
- To support a two way dialogue between transportation service providers and citizens/visitors. To enable citizens to provide crowd source data and feedback concerning perception of quality and satisfaction levels.

#### Business Benefits
- Better informed citizens and enhanced abilities for citizens to provide data and opinions on transportation service delivery.

#### Success Criteria
- Higher satisfaction levels among citizens and visitors
- Higher level of connectivity between citizens, visitors and transportation service providers
- Better understanding of prevailing transportation conditions
- Better understanding of citizen sentiment

#### Source Data
- Cell phone location data
- Citizen perception data
- Crowd sourced sentiment and perception
- Transportation performance data

#### Expected Outcome of Analysis
- Better traveler information to citizens
- Ability to utilize crowd source data from citizens
- Understanding of citizen sentiment based on integration with cell phone location data

#### Challenges
- Suitable data collection app that can also enable user perception feedback
- Determining privacy policy
- Defining data sharing agreements
- Isolating transportation and location specific sentiments from general sentiment data

#### Analytic Techniques
- Citizen satisfaction index
- Integrating user perception and crowd sourced data with transportation performance data
- Incident detection

#### References
Owner: Bob McQueen
### 12. Project tracking and coordination

**Objective / Problem Statement**
- Coordinate project delivery across geographic regions
- Minimize conflict between projects
- Maximize synergy between projects

**Business Benefits**
- Reduce project cost
- Reduce project risk
- Reduce congestion and delay

**Success Criteria**
- Reduction in project cost
- Reduction in project risk
- Maximizing synergy between projects

**Source Data**
- Project location
- Project type
- Resources involved
- Project cost
- Project risk

**Expected Outcome of Analysis**
- Better coordination between projects
- Avoidance of additional risk
- Optimizing project delivery

**Challenges**
- Obtaining data
- Combining data
- Developing suitable performance measures and analytics

**Analytic Techniques**
- Project cost index
- Project risk index
- Project synergy index

**References**
Owner: Bob McQueen
Smart Data Management

Data Sources
- Sensors
- Probes
- Databases
- Social
- Images
- Video
- Apps
- Unstructured

Ingest
- Streams
- Batch

Prepare
- Wrangle
- Cleanse
- Govern

Discover
- Search
- Access
- Analyze

Exchange
- Analytics
- Data

Data Lake: technology environment, security, metadata, lineage and operations

Smart City Services
- Asset and maintenance management
- Connected vehicle
- Connected, involved citizens
- Integrated electronic payment
- Intelligent sensor-based infrastructure
- Low cost efficient, secure and resilient ICT
- Smart grid, roadway electrification and electric vehicle
- Smart land-use
- Strategic business models and partnering
- Transportation governance
- Transportation management
- Traveler information
- Urban analytics
- Urban automation
- Urban delivery and logistics
Coherent Data Acquisition, Central Data and Analytics

Smart Data Management

Not So Smart Data Management
Smart Data Management Challenge

- Data, as a raw material, is perceived to be of little or no value
- This distorts benefit cost calculations with respect to data retention and management
- Consequently data is discarded
- The opportunity to convert data to information to insight to action is missed
- The misconception of little or no value of data is reinforced
Practical Approach to Smart Data Management

**Roadmap**
- Recommended

**Align**
- 1 week

**Create**
- 2-4 weeks

**Evaluate**
- 1 week

**Deploy**
- Further work

**Align**
- Document use case detail
- Data confirmation
- Assign Insight Pod team
- Assign Data Pod team
- Business client role defined

**Create**
- Load & prep data
- Develop analytics & models
- Develop early insights
- Iteration phases with business
- Finalize insights

**Evaluate**
- Final recommendations
- Document ROI
- Deployment plan
- Report write up
- Executive Presentation

**Deliverable**
- Scope Document
- Project Plan

**Deliverable**
- Analysis, Models & Code
- Insight Report & Findings

**Deliverable**
- Report & Presentation
Planning a Smart City

- Departure points
- Roadmap
- Future vision
- Preservation of legacy investment
- Coordination of future investments
- Possible departure points:
  - Integrated payment systems
  - Connected citizens and visitors
  - Transportation management
Evaluating the Effects of Investments

### Planning factors
- Cost benefit
- Legacy investment
- Policy priorities
- Service evolution over time, space and service quality

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<th>Benefits summary</th>
<th>Annual lifecycle benefits</th>
<th>Lifecycle cost</th>
<th>Benefit cost ratio</th>
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Review Instructional Objectives

1. Define a smart city
2. Identify importance of transportation in a smart city
3. Define the role of connected and autonomous vehicles in the smart city
4. Define Big Data
5. Define big data analytics and relevance to transportation
6. Explain the value of Use Cases
7. Discuss Smart Data Management
8. Define an effective approach to Smart Data Management
9. Discuss a planning approach to smart cities
10. Define a benefit and cost approach
Thank you for your Time and Attention

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• Latest book:
  Big data Analytics for Connected Vehicles and Smart Cities
  Artech House, published August 31, 2017