

Big Data Analytics, Connected Vehicles and Smart Cities

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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
- Benefit and cost approach

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?

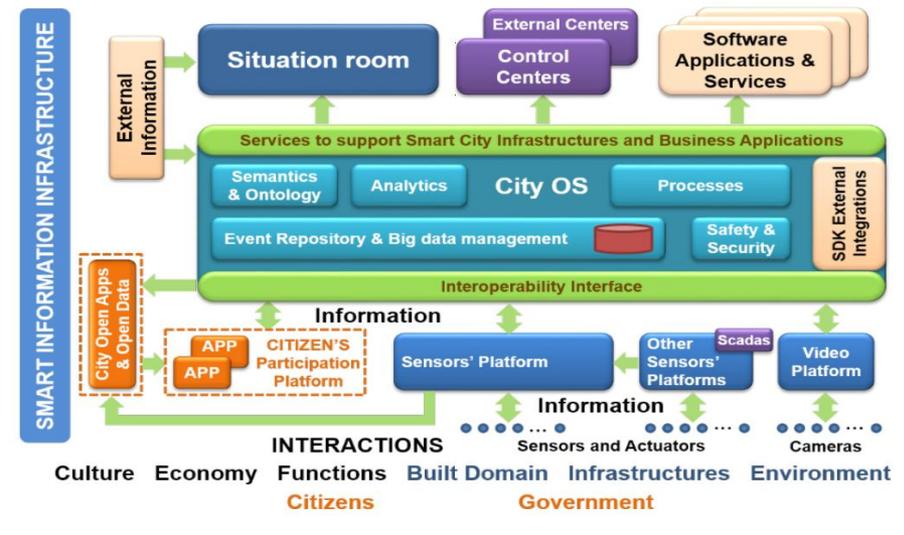
- Energy
- Smart Buildings
- Smart healthcare
- Smart education
- Smart retail
- Utilities
- Manufacturing
- Urban Agriculture
- Transportation



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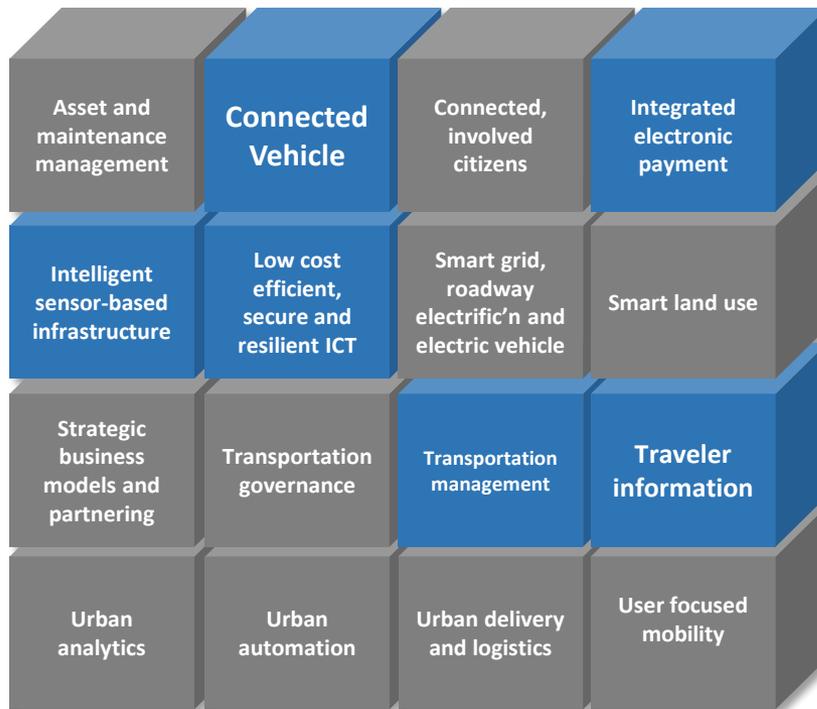
Transportation in Smart Cities

- 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



_CPA-I_001-v2_Anatomy City Anatomy: A Framework to support City Governance, Evaluation and Transformation Developed by Task Team - ancha 6 November 2015
http://www.cptf.cityprotocol.org/CPAI/CPA-I_001-v2_Anatomy.pdf

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



Paraphrased from the speech by Samuel J. Palmisano, Intelligent Transportation Society of America, 2010 Annual Meeting & Conference, Houston, Texas, May 5, 2010

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.



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*

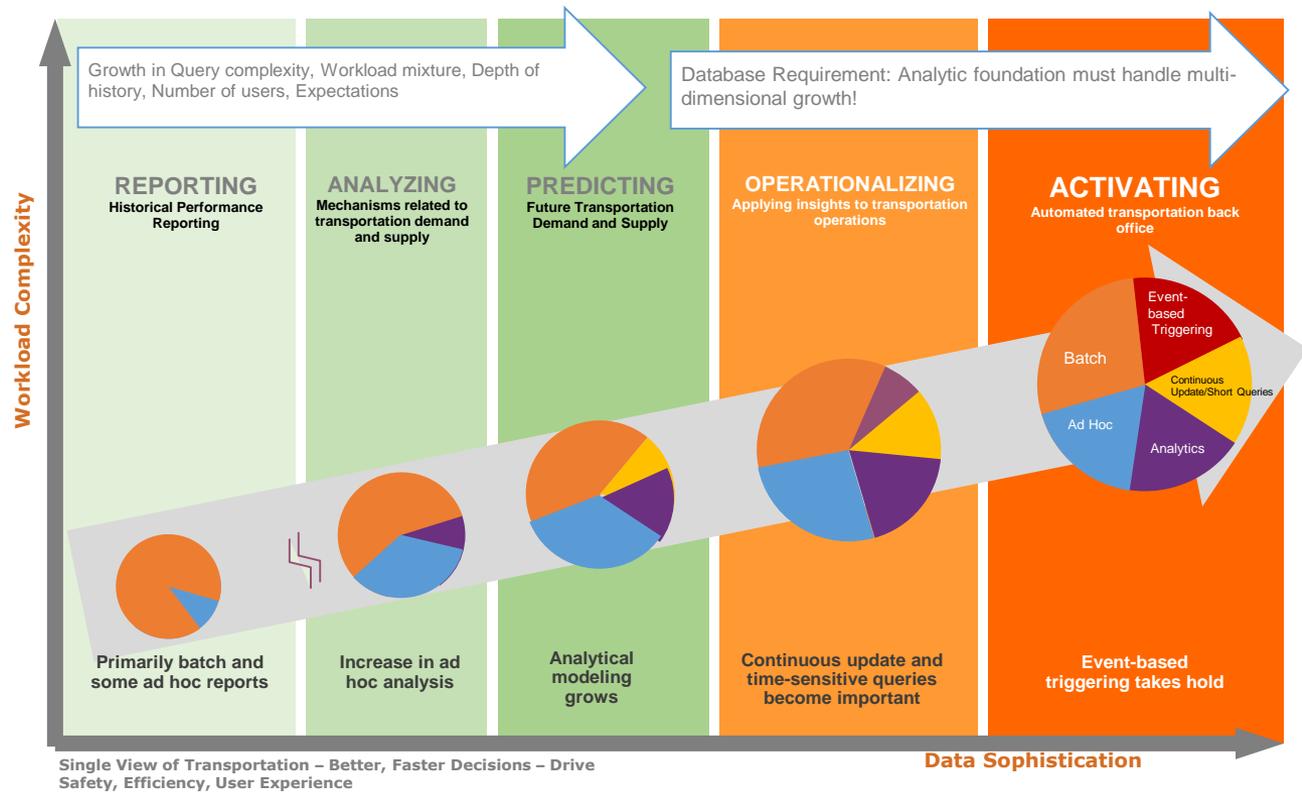
Not New

Most big data use cases are variations on:

- **Safety,**
- **Efficiency**
- **User experience**

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

Towards Automation



What are Big Data Analytics?

Services	Analytics
Asset and maintenance management	Asset performance index, asset maintenance standards compliance measure, optimal intervention point analytic
Connected vehicle	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
Connected, involved citizens	Citizens awareness levels index, citizens satisfaction levels
Integrated electronic payment	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
Intelligent sensor-based infrastructure	Data quality index, transportation conditions index, trip time variability index
Low cost efficient, secure and resilient ICT	Network load compared to capacity index, network latency, cost of data transfer, network security index
Smart grid, roadway electrification and electric vehicle	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
Smart land-use	Observed trip generation rates for different land uses, observed actual trips between zones, land value transportation index, zone accessibility index
Strategic business models and partnering	Percentage of private sector investment, number of partnerships, improvement in service delivery for each private sector dollar invested
Transportation governance	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
Transportation management	Mobility index, citywide job accessibility index, citywide transportation efficiency index, reliability index, end-to-end time including modal interchanges index
Traveler information	Traveler satisfaction index, decision quality information index, behavior change index
Urban analytics	Number of analytics in use, value of services managed by analytics, money saved through efficiencies gained by analytics
Urban automation	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
Urban delivery and logistics	Average cost of urban delivery, average time for end-to-end delivery, freight and logistics user satisfaction index, freight management satisfaction index
User focused mobility	Citywide mobility index, user satisfaction index, transportation service delivery reliability index

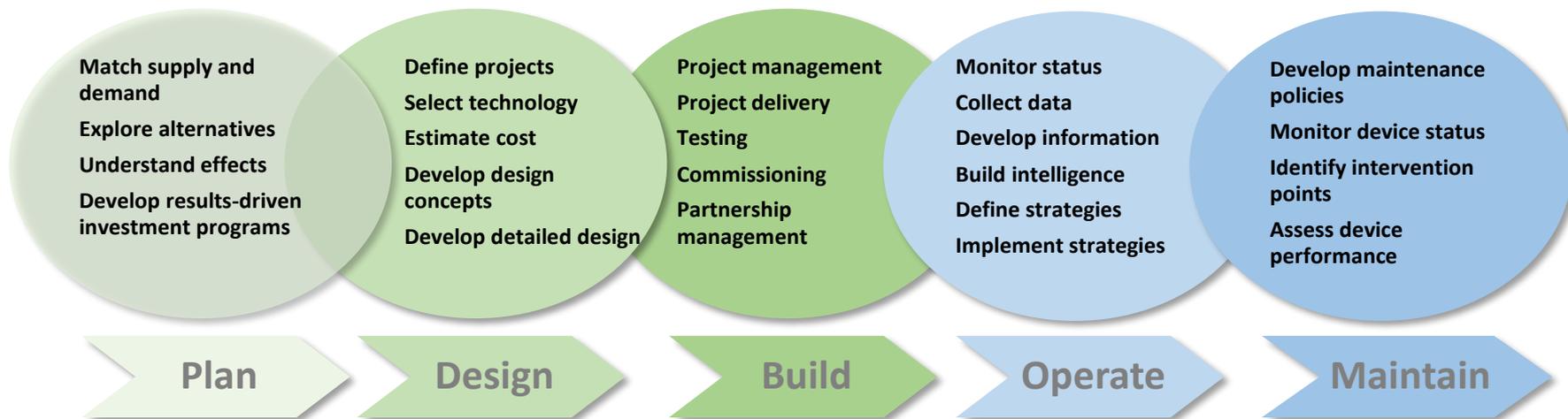
Getting What You Want

- 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



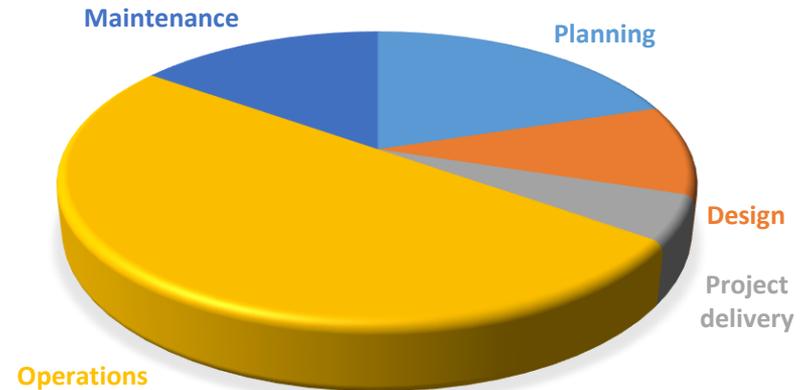
Focus on Operations

- Opportunities and challenges
- Illustrating the value of analytics in operations through Use Cases



Importance of 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



	Proportion of the data originating
Planning	20%
Design	10%
Project delivery	5%
Operations	50%
Maintenance	15%
Total	100%

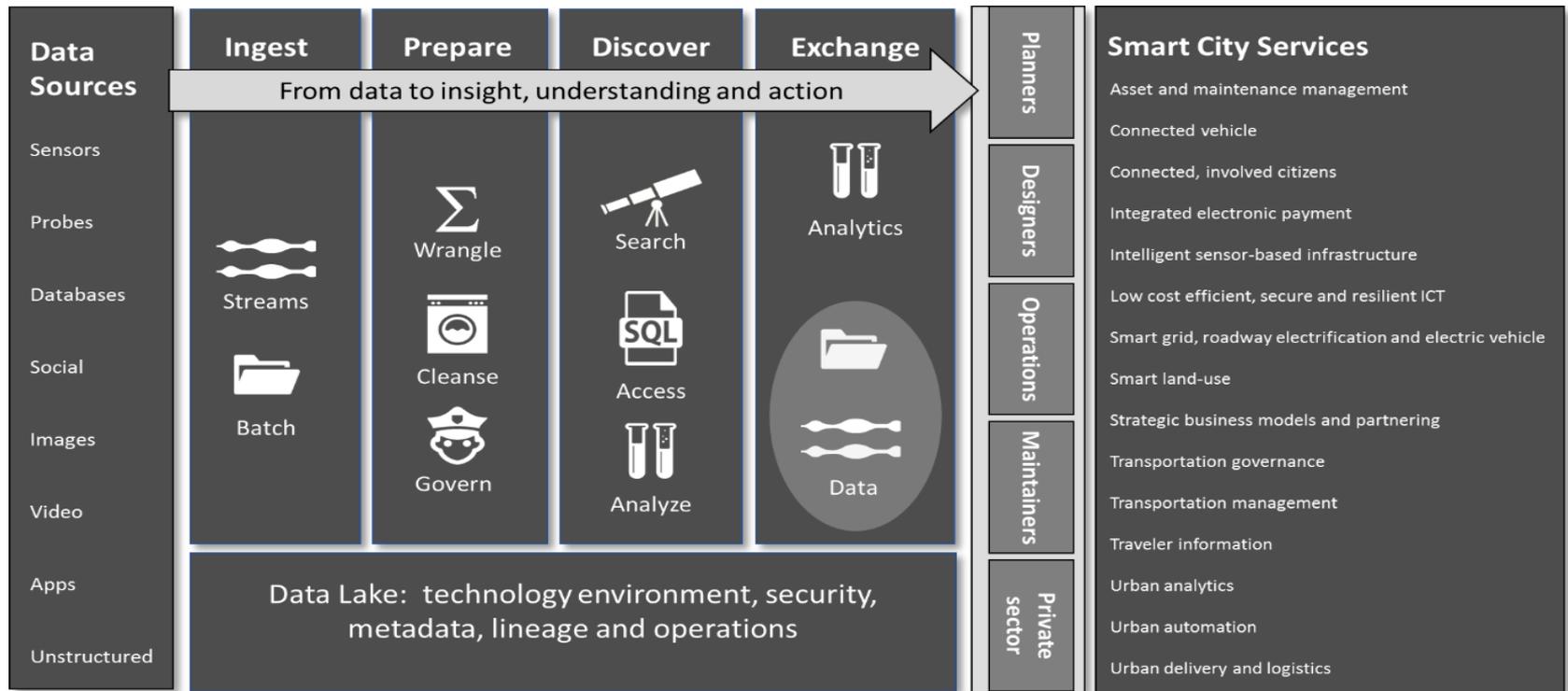
Operations Challenges



Operations Use Case Examples

Transportation Operations Use Case Catalog Version 1					
1	Traffic anomaly detection and communications	2	Towing and recovery management	3	Results driven investment
4	Asset management	5	Transportation network management	6	Transportation systems management and operation impact analysis
7	Developer fee management	8	Regionwide safety analysis	9	Regionwide speed in bottleneck analysis
10	Mobility as a service	11	Connected citizens and travelers	12	Project tracking and coordination

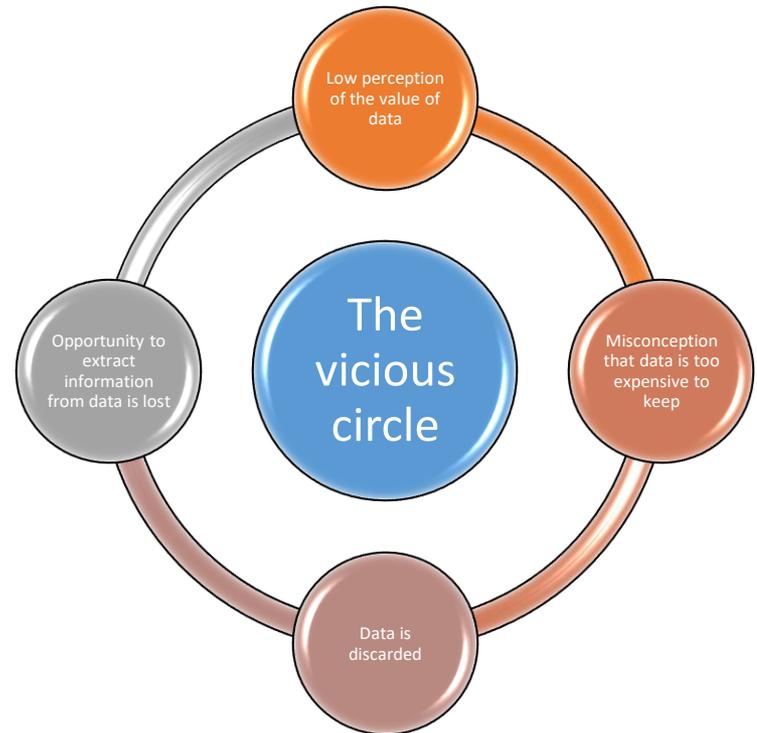
Smart Data Management



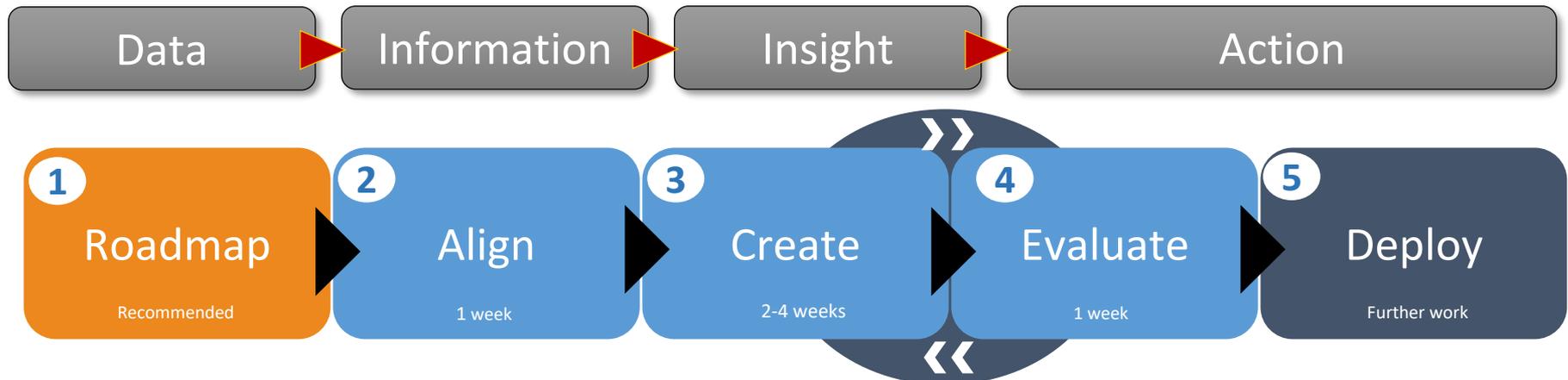
Open, Decentralized, Mobility

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



Smart Data Management Approach



Align	Create	Evaluate
<ul style="list-style-type: none"> Document use case detail Data confirmation Assign Insight Pod team Assign Data Pod team Business client role defined 	<ul style="list-style-type: none"> Load & prep data Develop analytics & models Develop early insights Iteration phases with business Finalize insights 	<ul style="list-style-type: none"> Final recommendations Document ROI Deployment plan Report write up Executive Presentation
Deliverable	Deliverable	Deliverable
<ul style="list-style-type: none"> Scope Document Project Plan 	<ul style="list-style-type: none"> Analysis, Models & Code Insight Report & Findings 	<ul style="list-style-type: none"> Report & Presentation

Evaluating the Effects

Planning factors

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

Benefits summary	Annual lifecycle benefits	Lifecycle cost	Benefit cost ratio
Asset and maintenance management	\$518,357	\$5,183,571	0.1
Connected vehicle	\$670,460,315	\$145,547,227	4.6
Connected, involved citizens	\$86,125,000	\$12,964,286	6.6
Integrated electronic payment	\$430,625,000	\$36,332,842	11.9
Smart grid, roadway electrification and electric vehicle	\$4,383,242,730	\$144,597,981	30.3
Smart land use	\$114,790,926	\$14,360,686	8.0
Transportation management	\$354,309,126	\$13,913,643	25.5
Traveler information	\$86,125,000	\$16,314,286	5.3
Urban automation	\$4,025,301,631	\$268,600,049	15.0
Urban delivery and logistics	\$287,477,315	\$15,380,667	18.7
User focused mobility	\$502,289,815	\$55,428,571	9.1
Direct benefit services total	\$10,941,265,216	\$728,623,810	15.0
Intelligent sensor- based infrastructure		\$34,557,143	
Low cost efficient, secure and resilient ICT		\$59,000,000	
Urban analytics		\$4,380,000	
Strategic business models and partnering		\$2,347,210	
Transportation governance		\$2,347,210	
Indirect benefit enabler services		\$102,631,562	
Grand totals	\$10,941,265,216	\$831,255,372	13.2

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

