Asset Management for Tough Economic Times:
Cross Asset Analysis and Optimization

Pavement Evaluation 2010
October 26th, 2010

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What is Transportation Asset Management?

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Transportation Asset Management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their lifecycle.

It focuses on business and engineering practices for resource allocation and utilization, with the objective of better decision making based upon quality information and well defined objectives.

Source: AASHTO Sub Committee on Asset Management

TAM Addresses 5 Core Questions

1. **What is the current state of my assets?**
2. **What are my required levels of service and performance delivery?**
3. **Which assets are critical to sustained performance delivery?**
4. **What are my best investment strategies for operations, maintenance, replacements and improvement?**
5. **What is my best long-term funding strategy?**

Source: Multi-sector Asset Management, Publication No. FHWA-HIF-09-022

The State of the Industry

State of the Industry

- **A lot of money being spent**
  - Maintenance organizations in DOTs and DPWs typically have the largest capital and consumable inventories
  - The roadway maintenance budget is typically one of the ***top 3*** areas of spend in an agency
- **But is it enough, is it being spent on the right projects and at the right times?**

Source: ASCE – American Society of Civil Engineers

Costs Increasing and Revenue Decreasing…

The Review, June '10

- **Increasing Costs**
  - Lisbon's average cost for blacktop reached a record $125 per yard in 2010; nearly doubling over the past 10 years
- **Decreasing Revenue**
  - Lisbon's chief sources of funding are: license plate taxes and a portion of the state gasoline tax
  - As people switch to more fuel-efficient cars and fewer vehicles are registered, revenue decreases

The United Kingdom

*In March, a young army officer was killed when his bicycle was hit by a truck; the inquest was told that the **driver swerved to avoid a pothole…***

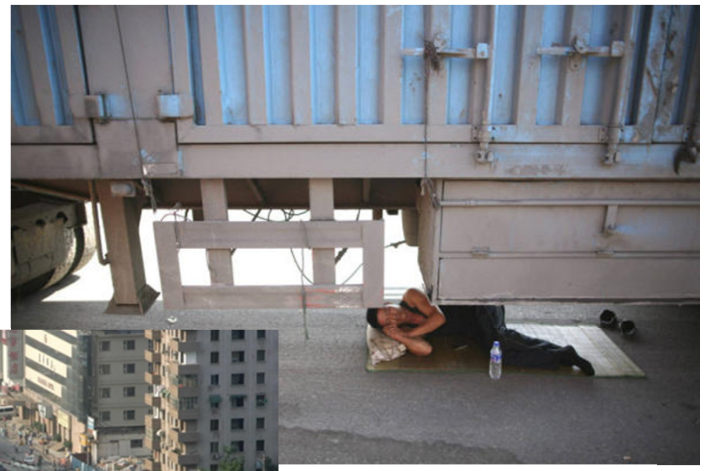
The Telegraph, Sept '10

- "A ***dreadful winter, budget cuts and poor repairs*** mean the pothole problem persists and Britain's asphalt arteries are crumbling..."
- "…the amount spent on pothole repairs ***[increased by] 75 per cent*** in England."
- "Nine out of 10 local authorities believe the ***shortage of maintenance funding poses a threat to safety…***

The People's Republic of China

Wall Street Journal, Aug '10

- **The recent jam in Beijing:**
  - 11 days to clear; 60 miles long
  - 10,000 trucks; almost all carrying coal; the #1 source of energy for China
  - A combination of peak seasonal travel, increased freight traffic and road construction
- **More to Come?**
  - Another 1,900 vehicles are added to Beijing's streets <u>each day!</u>

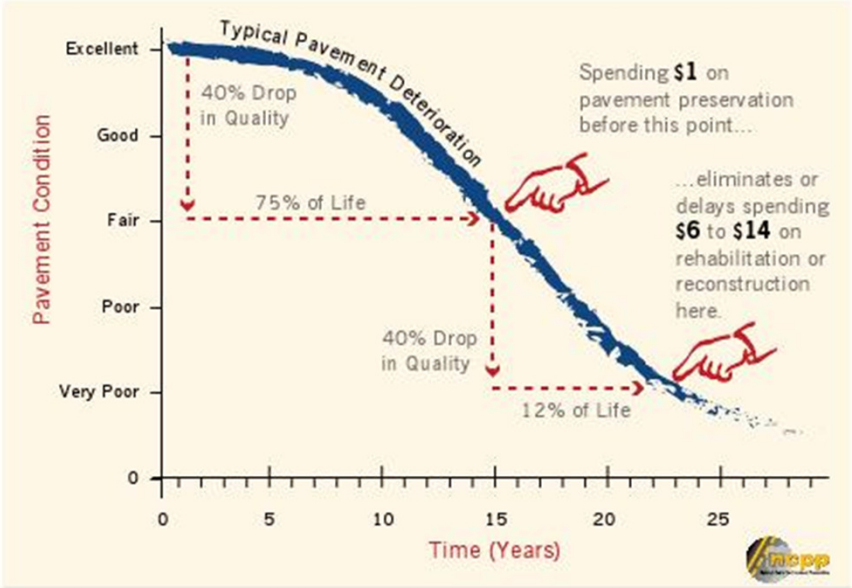


Infrastructure Investment Around the World

- **China spends 9% of its Gross Domestic Product on its infrastructure…**
- **India spends 5%**
- **Australia spends 4.5%**
- **The United States spends less than 2 %!**

Sources: www.livemint.com (Leading Indian Business Newspaper and WSJ Partner)
Treasury/CEA report, "An Economic Analysis of Infrastructure Investment,"

What do We Know?



- **Pay me now…or pay me (more) later…**
- **Investing money on the *right roads*, for the *right repairs* at the *right time* pays off in the long run**

Where on the Curve are We?

“One-third of America's major roads are in poor or mediocre condition and 36% of major urban highways are congested”

Source: ASCE – American Society of Civil Engineers; 2009 Report Card

Where on the Curve are We?

Road crew in Jamestown, N.D.; turning asphalt roads into gravel ones…

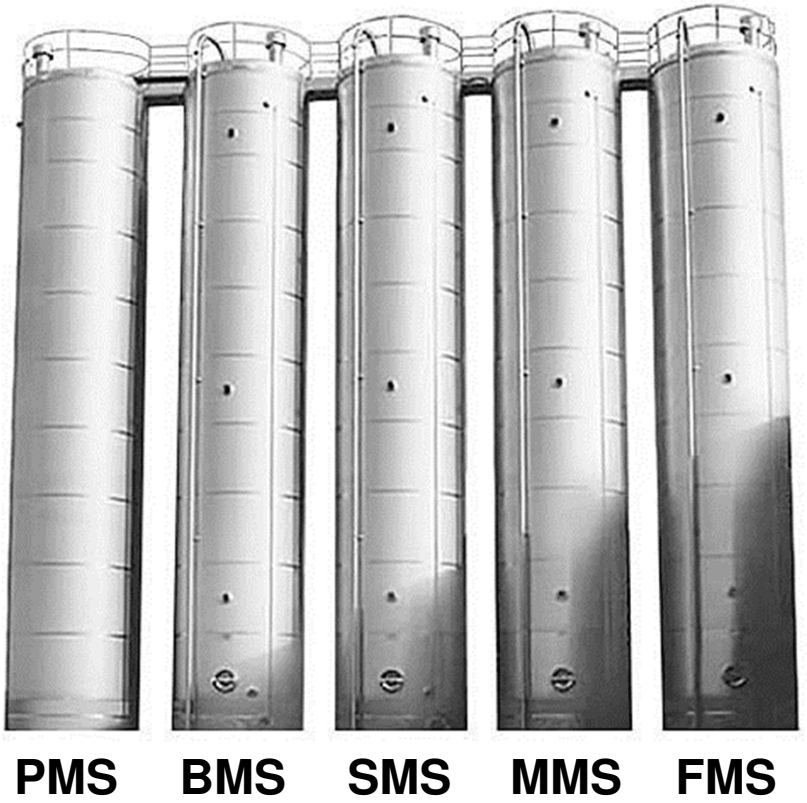
Wall Street Journal, July '10

- In Michigan, at least 38 of the 83 counties have converted some asphalt roads to gravel in recent years
- Last year, South Dakota turned at least 100 miles of asphalt road surfaces to gravel
- Counties in Alabama and Pennsylvania have begun downgrading asphalt roads to cheaper chip-and-seal road, also known as "poor man's pavement"
- Some counties in Ohio are simply letting roads erode to gravel

Traditional Approach to Asset Management

Life in Silos

- **You keep your data; I'll keep mine**
- **Big-picture view of the network not possible**
- **"Siloed" decisions made**
  - 43rd Street is reconstructed in June to restore pavement condition
  - In September a large trench is cut on 43rd Street as part of the watermain replacement program



Reasons for the Siloed Approach

“Most transportation funding comes with strings attached and program managers are naturally reluctant to invest in other programs or agencies, given needs typically outstrip available resources”

Source: NCHRP 664: Measuring Transportation Network Performance

Reasons for the Siloed Approach

- **Job security ("Turf wars")**
- **Different database formats**
- **Numerous Legacy applications**
- **Different reference systems**
  - Road log (milepoint)
  - Parcels
  - Street addresses
  - X, Y and Z coordinates

Limitations of the Siloed Approach

- A very narrow view; you consider the network along one dimension
- Therefore, you miss the opportunity to see the big picture and the interactivity of the network elements
- You end up spending more time in the field than you need to
- To the system users this makes no sense

Key Concepts in the Modern Approach to Asset Management

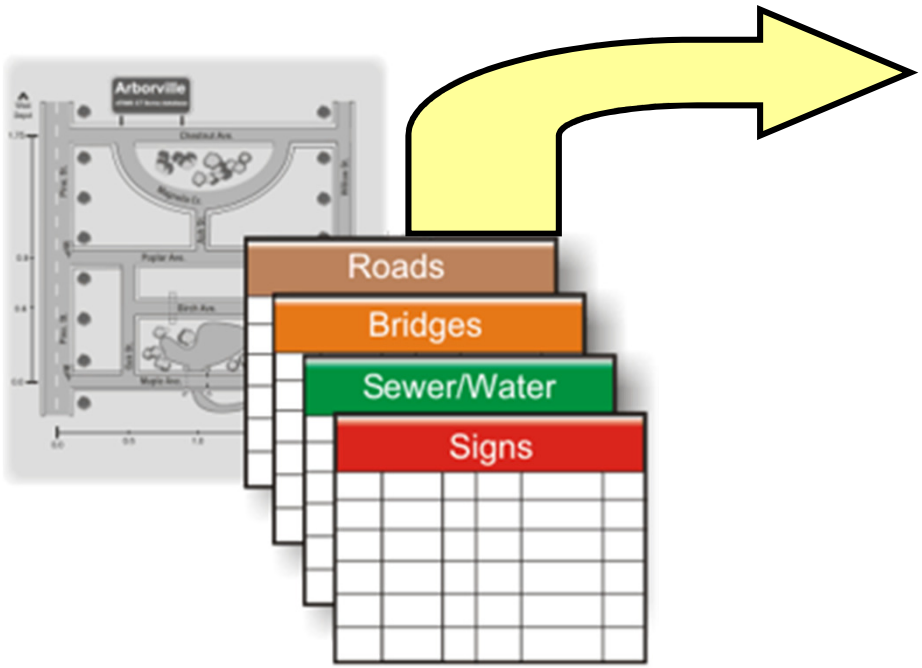
Operational vs. Tactical vs. Strategic Asset Management

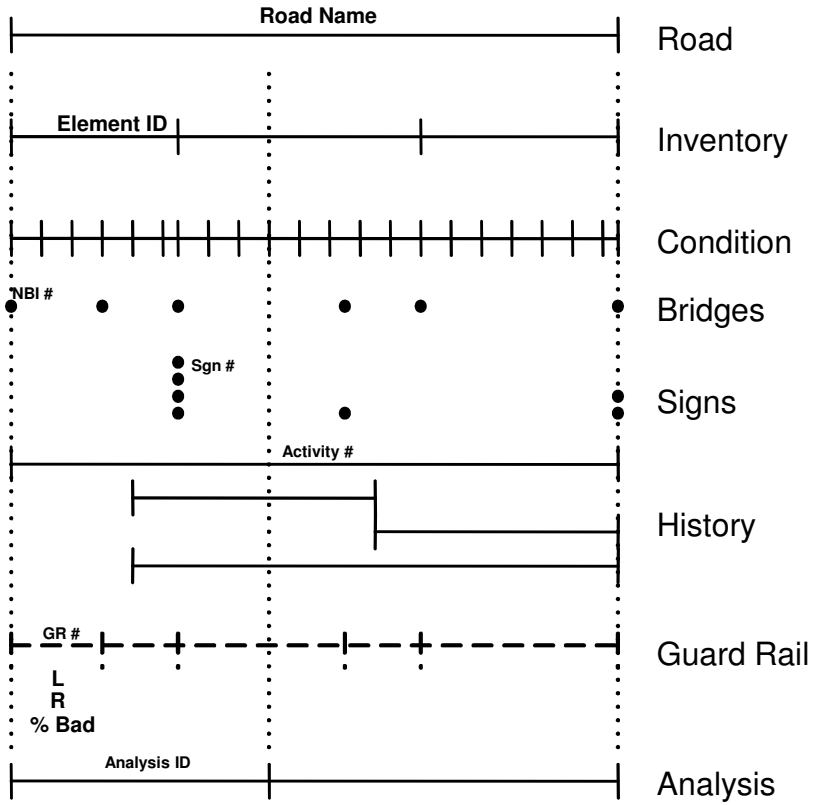
- **Operational Asset Management**
  - Implementation of Asset Management Plans
  - Day to Day information needs and updates
  - Performance Indicators are Activity Based
- **Tactical Asset Management**
  - Individual Asset Analysis or Group of Assets (BMS / PMS)
  - Specific Condition Performance Indicators to each asset
  - Goals are usually Condition Based
  - Asset Management Plans at this level
- **Strategic Asset Management**
  - Enterprise Wide Asset Management
  - Strategic Level Performance Indicators
  - Strategic Analysis – Funding Needs, Cross Asset, Tradeoffs
  - Transportation Network as a Whole – Not Individual Assets
  - Long Range Plan and Vision at this level

Tearing-down the Silos…

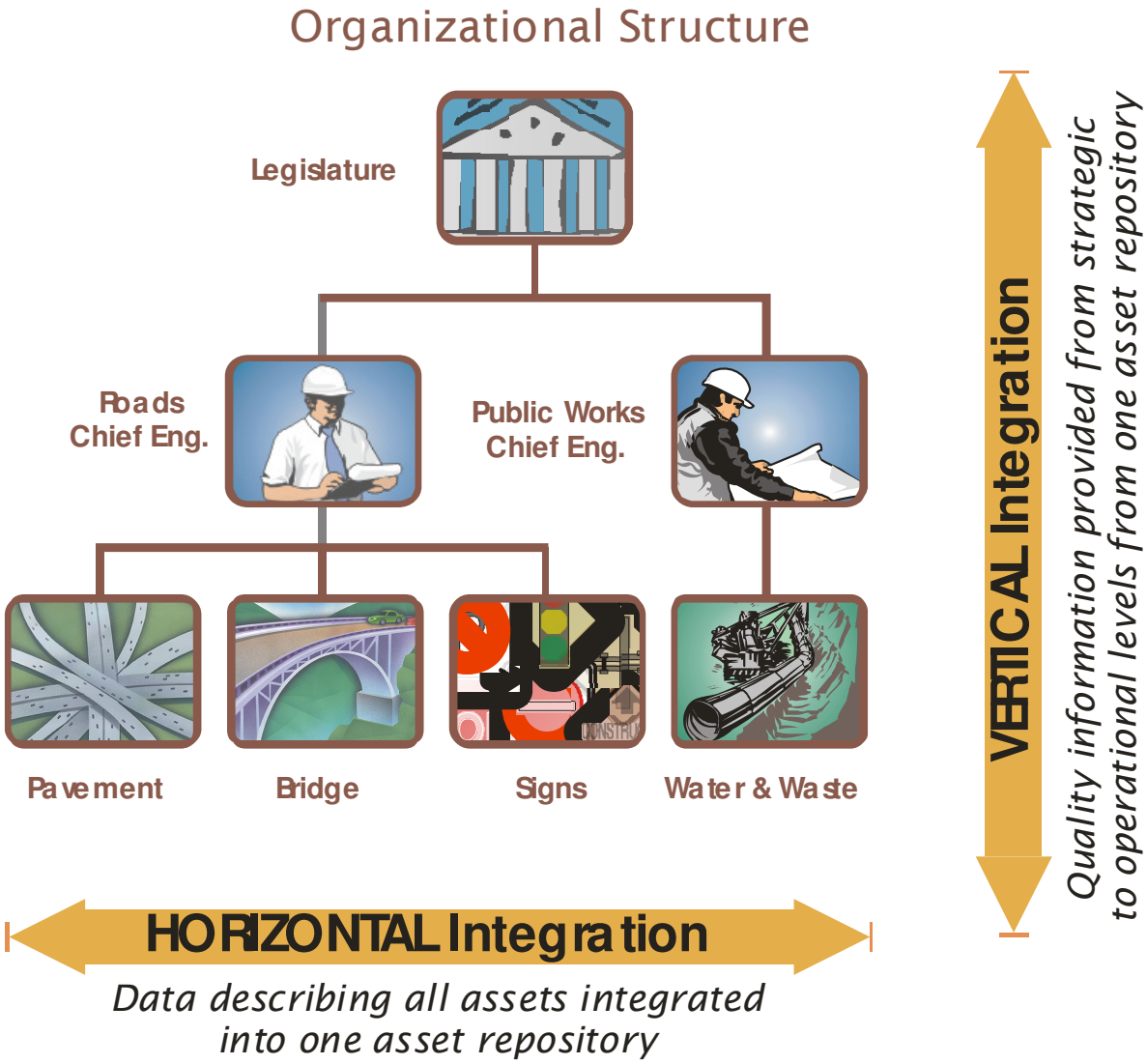
- **A single database or data-warehouse to store and provide access to data**
- **Multiple location referencing systems "transformed" to permit queries across all data types**
- **Data-sharing makes data analysis more meaningful**
  - What is the roadway texture at my top ten highest crash incident locations?
  - Which roads are both slated for spot safety improvements as well as for surface repair/replacement?

Getting Onto the Same Page:
Dynamic Segmenting and Data Transformation





Horizontal and Vertical Integration



Modeling Multiple Variables

	Original Benefit Weightings		
Social	**Pavements**	**Structures**	**Safety**
Human Health	1.17	2.25	2.83
Community Connectivity	3.00	1.83	1.17
Cultural / Historical	1.83	2.92	1.00
Multi-Modal	2.83	1.17	2.00
Homeland Security	1.00	2.33	2.50
Economic	**Pavements**	**Structures**	**Safety**
Productivity	2.33	2.67	1.00
Congestion	2.17	2.67	1.67
Employment	3.00	2.08	1.00
Tax Burden	2.83	2.33	1.17
Trade	3.00	2.17	1.00
Recreation / Tourism	3.00	2.00	1.00
Environmental	**Pavements**	**Structures**	**Safety**
Pollution	2.67	2.00	1.17
Energy Consumption	2.50	2.17	1.17
Habitat Preservation	2.67	1.67	1.33
Aesthetics	1.83	3.00	1.00
Total	**35.83**	**33.26**	**21.01**

UDOT's "Triple Bottom Line"

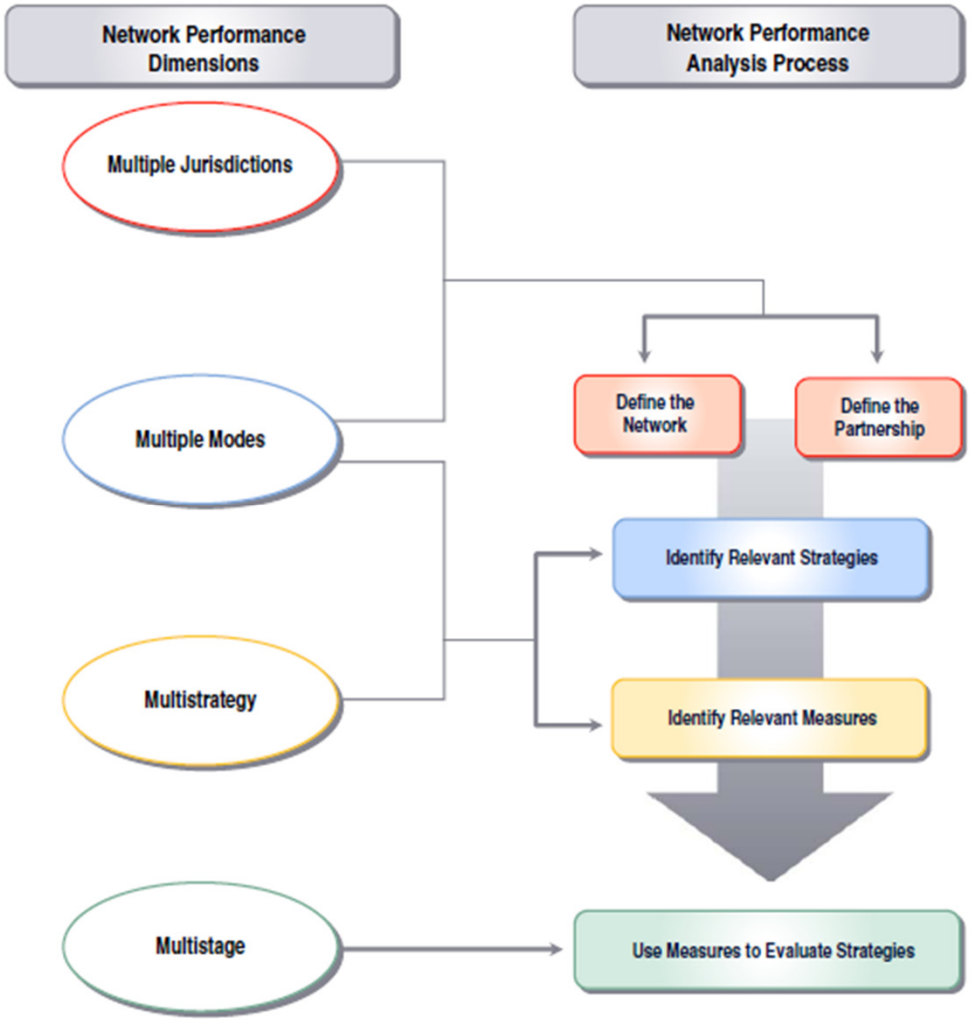
- ***Everything*** **viewed as an "asset" of the transportation system**
- **Different types of assets deliver different types and levels of value to the system users**
- **Improving one type of asset to deliver one kind of value may negatively impact another asset or value**

The Evolution of Performance Measures…

- **Traditional, non-system-level performance measures were developed in the 50s with an "engineering, capacity-building view in mind and focus on facility-type specific measures of performance on individual segments"**
- **New measures not only consider *inputs* (e.g., time, staff, and funding) and *outputs* (e.g., pavement quality and congestion) *but increasingly focus on measuring outcomes* from the perspective of both system managers and system users**

Source: NCHRP 664: Measuring Transportation Network Performance

Network Performance Measurement Framework



Source: NCHRP 664: Measuring Transportation Network Performance

What is the *Right* Approach?

- **There isn't ONE right answer**
- **Depends on a lot of factors:**
  - Current network situation; are you in catch-up mode?
  - Funding scenario now and in the future; constant, decreasing, increasing
  - Political considerations
- **You've got to start somewhere…**

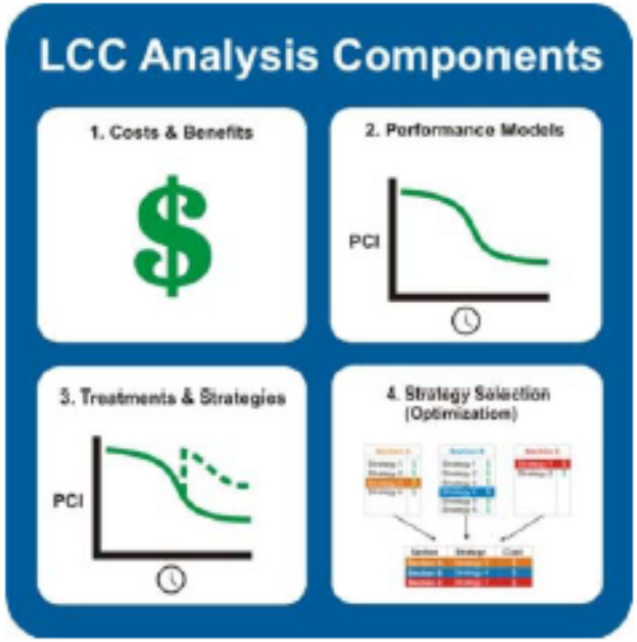
…with hindsight you'll realize that it *wasn't* the right spot!

Decision Making; Weighing All the Variables

Prioritization versus Optimization

- **Prioritization puts elements on a priority list indicating which elements are to be fixed first by:**
  1. Calculation of a priority number for each element
  2. Listing of the elements in the order of decreasing priority
  3. Selection of an applicable treatment for each element
  4. Terminating the list once the available budget is exhausted
- **Optimization focuses on the efficient allocation of limited budgets to achieve some objective**
  1. Optimization techniques involve examining the effects of various repair strategies on each element,
  2. And, the selection of a repair strategy for each element which meets the objective function and satisfies the constraints

Optimization using Life Cycle Cost Analysis (LCCA)



- **Used to compare different policies for building, maintaining or improving assets by estimating the future costs resulting from alternative policies**
- **Ultimate aim is to find a single strategy for each part of your asset network among the many in terms of life cycle costs to owners and users**
- **Optimization involves 2 elements:**
  - Something which you want to maximize or minimize, called the ***objective function***
  - Something which limits the choice of the objective function called the ***resource constraint***

Considering Costs (Roads Example)

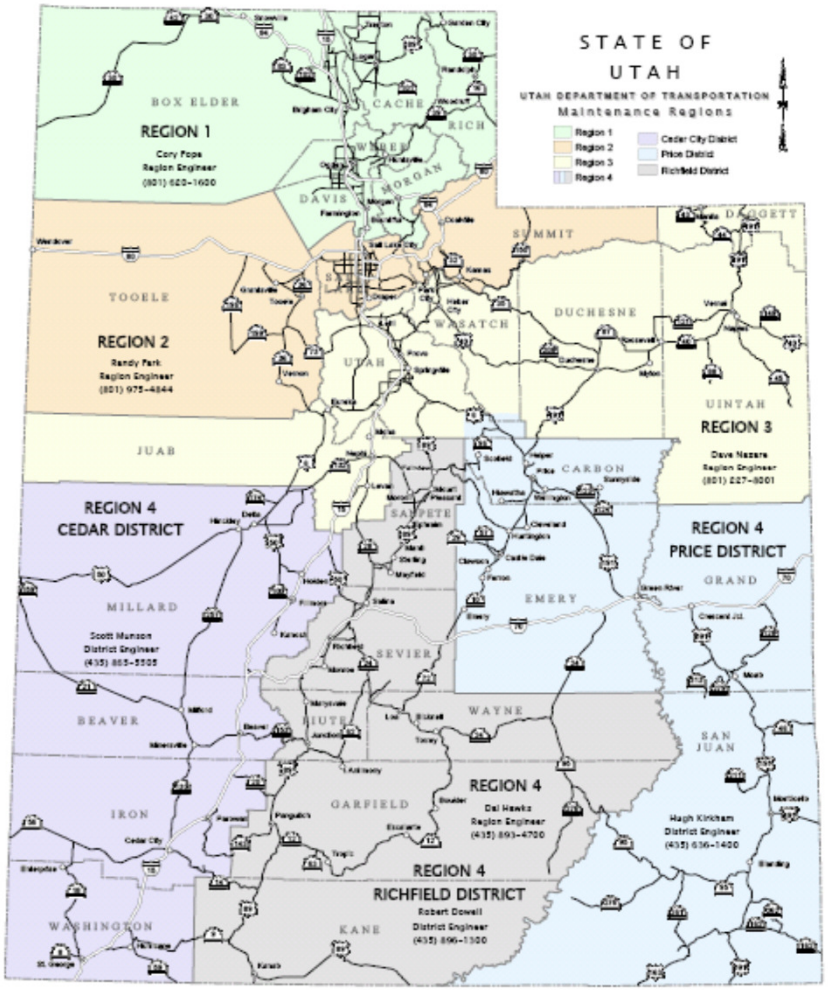
- **Owners**
  - **Capital or construction costs:** Initial cost to place the asset
  - **Maintenance and rehabilitation costs:** Money spent to maintain and preserve the asset at a specific service level
  - **Improvement costs:** Money spent to enhance the utility of the facility
  - **Operational costs:** Costs which do not necessarily affect the physical condition of the asset; for example the cost of collecting tolls or providing for traffic management
- **User Costs**
  - **Vehicle operation:** the costs of vehicle depreciation, repairs, fuel, tires and other running costs, usually expressed in $/mi/km.
  - **Passenger or freight time:** the value of the time in $/hour
  - **Accidents:** the costs ascribed to property damage (usually vehicles), injuries and deaths.
  - In the case of injuries there are direct cash costs of medical treatment, loss of earnings
  - Also intangible costs such as pain and suffering and loss of life

Incremental Benefit Cost Technique

- **Heuristic techniques used to improve the efficiency of analysis**
- **The most popular heuristic optimization technique used by agencies is called *Incremental Benefit Cost* (IBC) technique**
- **This approach determines the most incremental benefits per dollar invested**
- **IBC ratio is the ratio between the increase in benefit to the increase in cost between successive strategies**

Utah DOT Asset Management Case Study

Asset Management at UDOT



- **Population:** 2,800,000
- **Land Area:** 84,900 sq miles (11th Largest State)
- **Four Regions;** each split into 2 districts
- **1,728 employees**
- **5,840 miles of road**

UDOT's 4 Strategic Goals for Asset Mgmt

1. **Take Care of What We Have**
2. **Make the System Work Better**
3. **Improve Safety**
4. **Increase Capacity**

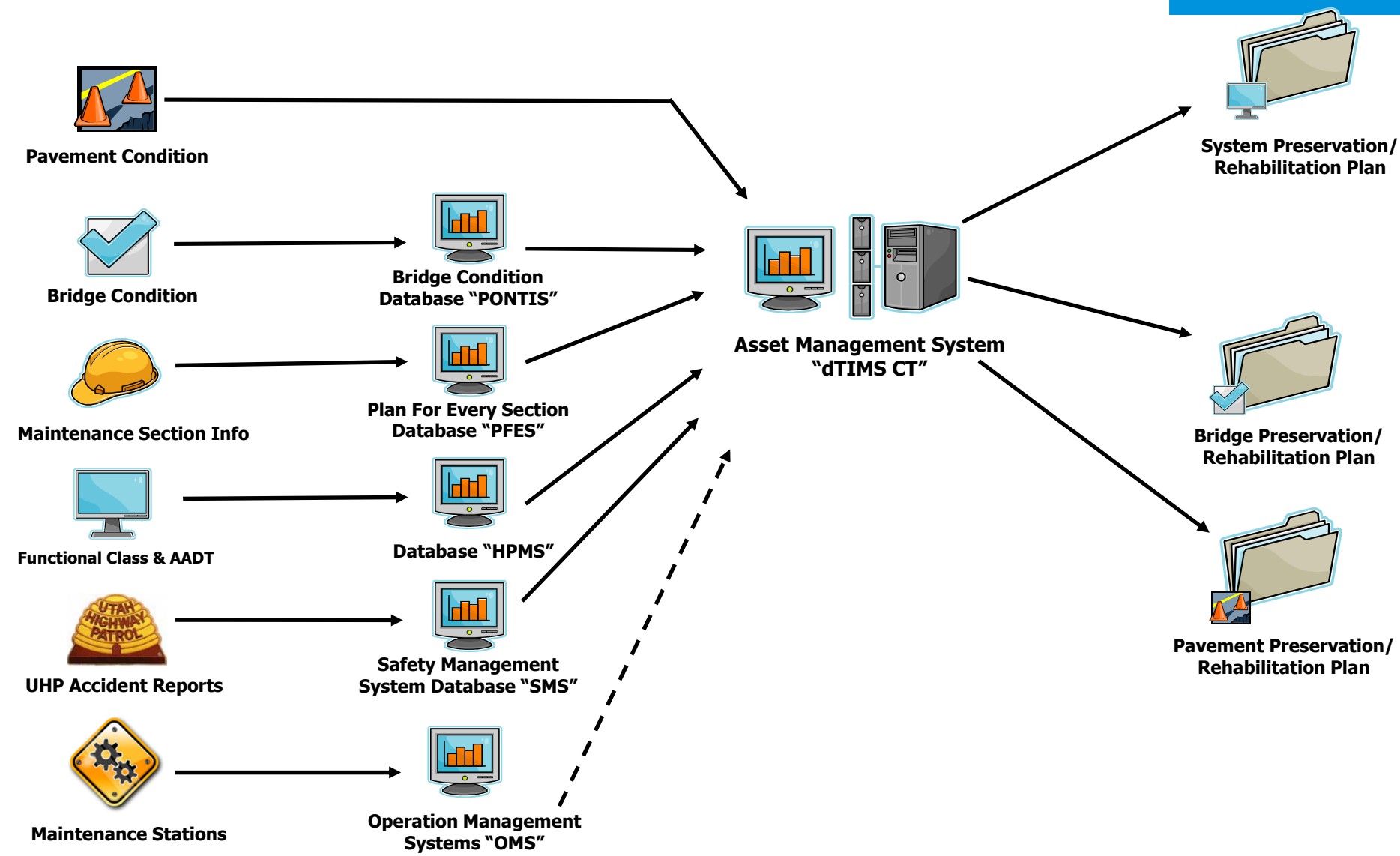
2009 STRATEGIC DIRECTION
& Performance Measures

Asset Management at UDOT

3. Improve Safety

- New and upgraded signal equipment
- Reduce run-off-the-road-crashes
- Install additional barriers
- Install additional rumble strips
- Pedestrian ramp projects
- Safety lighting projects
- Safe sidewalk projects

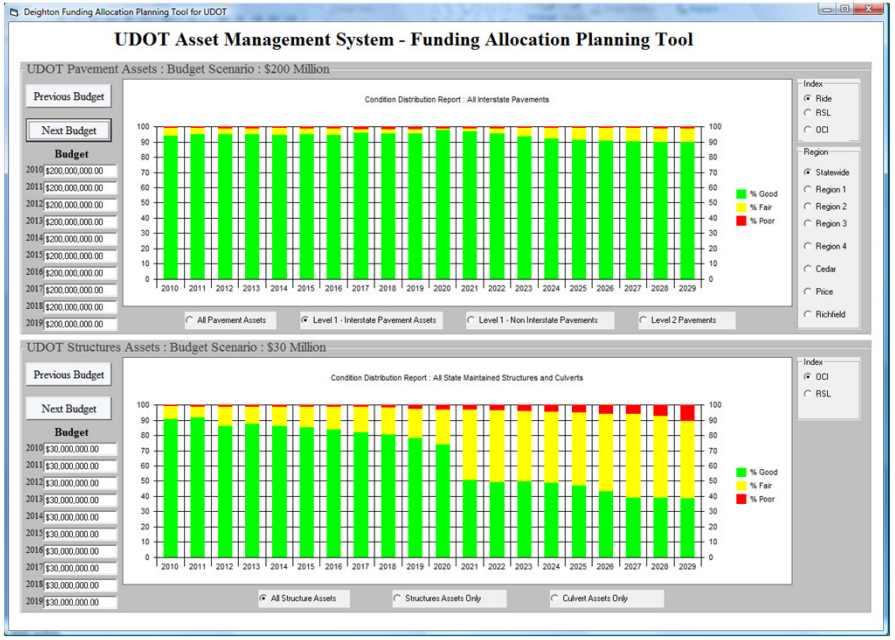
UDOT Asset Management Flow

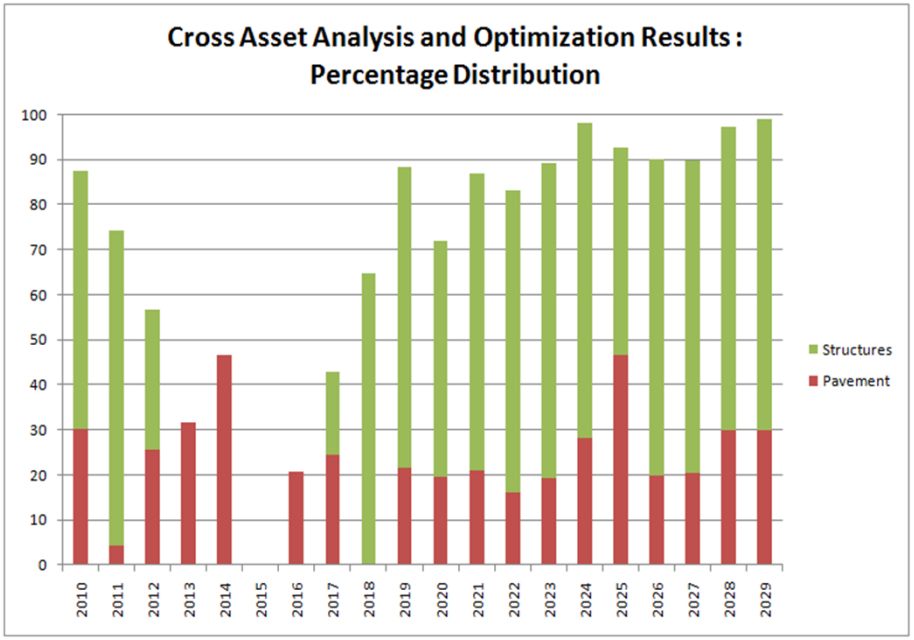


Asset Management Data Flow and Analysis

Asset Management System

Systems Preservation Plan:
Funding Needs and Cross Asset Trade-offs





Integrating Safety Index in the Asset Management Strategic Analysis

Safety with the Asset Management Strategic Analysis

- **Originally Safety was considered an "asset" just like a pavement or a bridge asset and analyzed on the mile by mile safety sections**
- **Original Safety weightings within the cross asset analysis and optimization were as follows:**

	Original Benefit Weightings		
Social	**Pavements**	**Structures**	**Safety**
Human Health	1.17	2.25	2.83
Community Connectivity	3.00	1.83	1.17
Cultural / Historical	1.83	2.92	1.00
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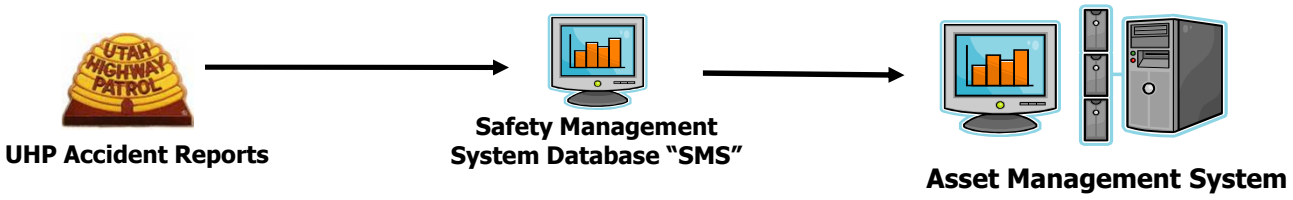
Safety Used to Aid in Pavement Project Selection

- **However, due to the limited funding; safety analysis was rolled into the pavement analysis**
- **Safety is thereby used to weigh pavement projects based on the safety index value**

Safety Factors	
Score	Factor
1,2,3	1.0
4,5,6	1.2
7,8,9	1.4

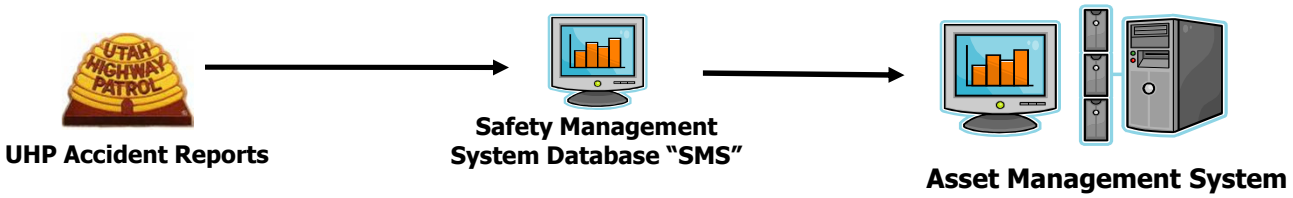
Benefit Values With Safety Rating Factor						
Section	Safety	Ben K = 1	Ben K = 0.75	Ben K = 0.5	Ben K = 0.25	Ben K = 0.15
A	1	29,345,831.16	1,962,474.01	131,238.55	8,776.45	2,974.55
A	5	35,214,997.39	2,354,968.81	157,486.26	10,531.74	3,569.47
A	9	41,084,163.62	2,747,463.61	183,733.97	12,287.03	4,164.38
B	1	2,934,583.12	348,982.71	41,501.27	4,935.36	2,105.82
B	5	3,521,499.74	418,779.25	49,801.53	5,922.43	2,526.99
B	9	4,108,416.36	488,575.80	58,101.78	6,909.51	2,948.15
C	1	293,458.31	62,058.88	13,123.85	2,775.36	1,490.81
C	5	352,149.97	74,470.65	15,748.63	3,330.43	1,788.97
C	9	410,841.64	86,882.43	18,373.40	3,885.50	2,087.13

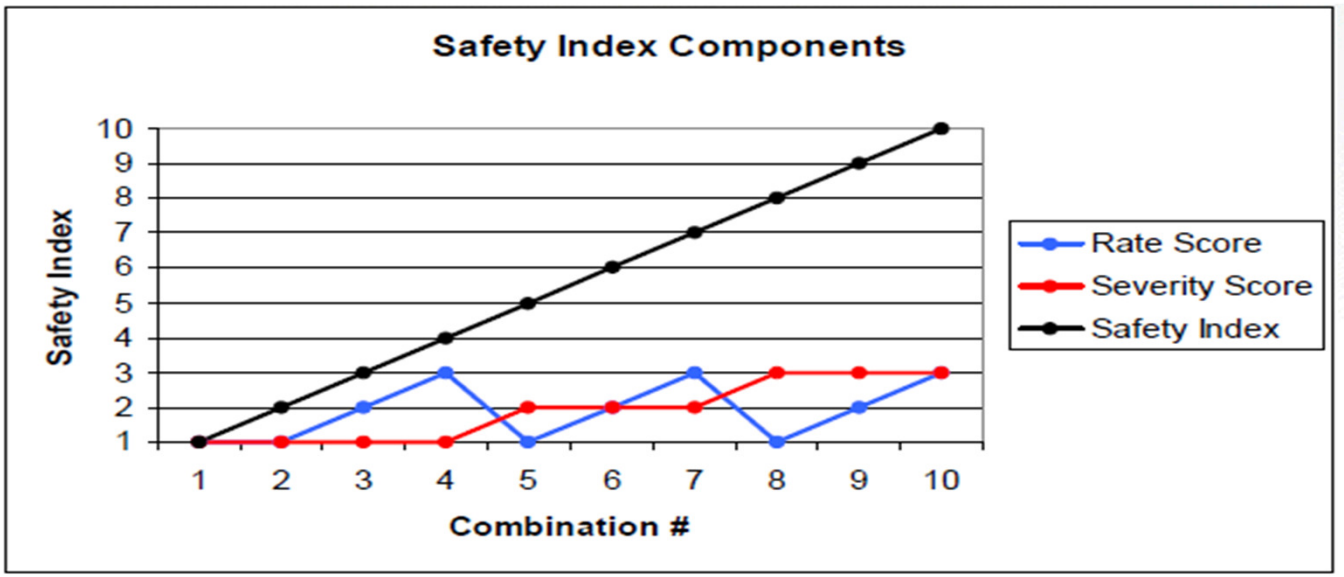
Safety Index; Turning Data into Information



- 3 years of crash location and crash severity data loaded into the AMS (dTIMS)
- Crash data is loaded as points; located by route, mile point and direction
- Crash data is transformed and summarized by the AMS on mile by mile segments

Combined Safety Index





Safety Index = (Crash Rate Score + 3 * Crash Severity Score) - 2

A Safety Index of 1 = no crash records

Projects Ranked According to Benefit to Safety

- Safety factor weighting used for cross asset analysis and optimization weightings
- 3 Sections, cost to repair identical; safety used to decide

Benefit Values With Safety Rating Factor						
Asset ID	Safety Score	Traffic AADT	Pavement Benefit	Bridge Benefit	AMS Benefit Pavement	AMS Benefit Bridge
A	1	50000	131,238.55	147,858.70	4,985,752.39	4,985,795.20
A	5	50000	157,486.26	147,858.70	5,982,902.86	4,985,795.20
A	9	50000	183,733.97	147,858.70	6,980,053.34	4,985,795.20
B	1	5000	41,501.27	46,757.02	1,576,633.34	1,576,646.88
B	5	5000	49,801.53	46,757.02	1,891,960.01	1,576,646.88
B	9	5000	58,101.78	46,757.02	2,207,286.68	1,576,646.88
C	1	500	13,123.85	14,785.87	498,575.24	498,579.52
C	5	500	15,748.63	14,785.87	598,290.29	498,579.52
C	9	500	18,373.40	14,785.87	698,005.33	498,579.52

Recap…

Closing Thoughts

- Asset management = spending your limited dollars wisely to deliver the best value
- Try to develop performance measures which consider outcomes that are relevant to you AND your Customers
- Don't be afraid to "start somewhere"
- Don't expect to get there in just one step; aim for continual improvement
- Leverage technologies that permit data sharing; you've invested significantly in collecting data, get the biggest benefit from it

And Now for Something Completely Different…

For More Information…

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Deighton provides Asset Management System consulting and software solutions to 250+ DOTs and DPWs worldwide; including nearly 40% of State DOTs

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