

Use of Management Science Analytics for Asset Management At TxDOT

**Ron Hagquist,
TxDOT Operational Excellence Office**

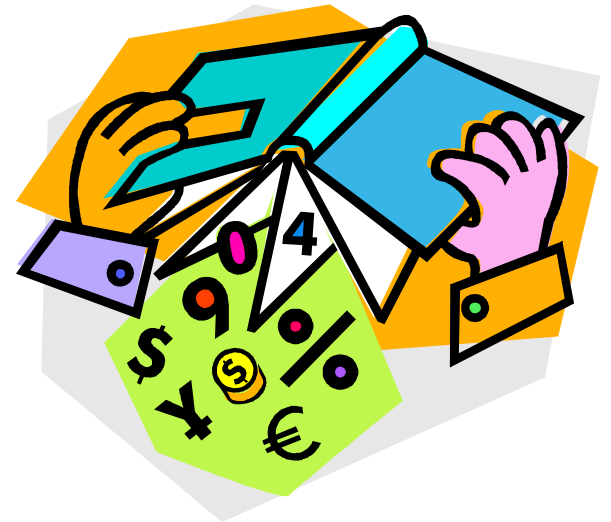
**Transportation Research Board
9th National Conference On Asset Management
San Diego
April 17, 2012**



1. Financial outlook

2. Ongoing and previous analytics projects

3. TxDOT strategic plan for analytics



*"Gentlemen, we are out of money.
We shall have to think."*



-Address to Parliament
by Winston Churchill

So...
how hard do WE have to think?

TRANSPORTATION ASSETS MANAGED BY TXDOT

Some numbers about assets....

\$51 Billion

*The cost if you
wanted to buy
100% of the assets
in General Motors.*

\$300 Billion

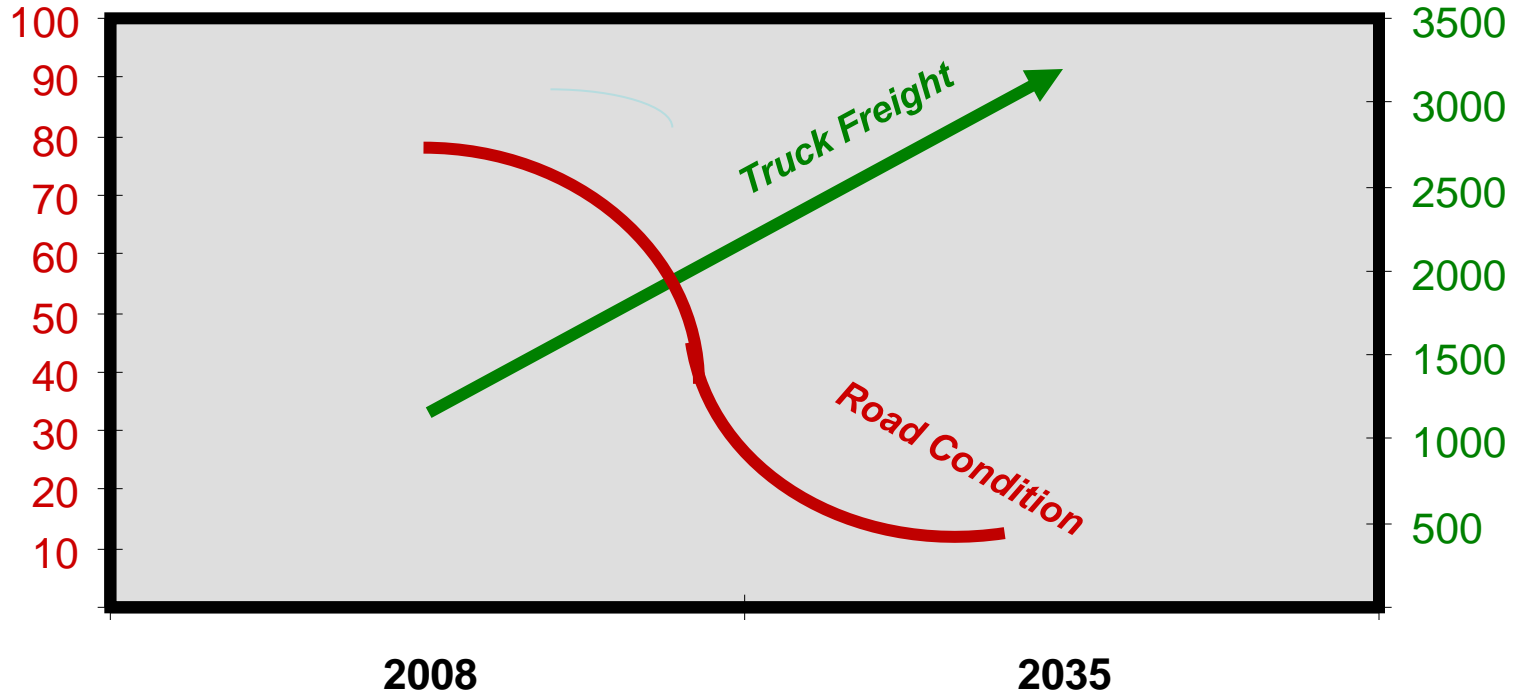
*The replacement
value of the **Texas
road system** assets
for which TxDOT has
sole responsibility.*

...extreemly conservative !!!

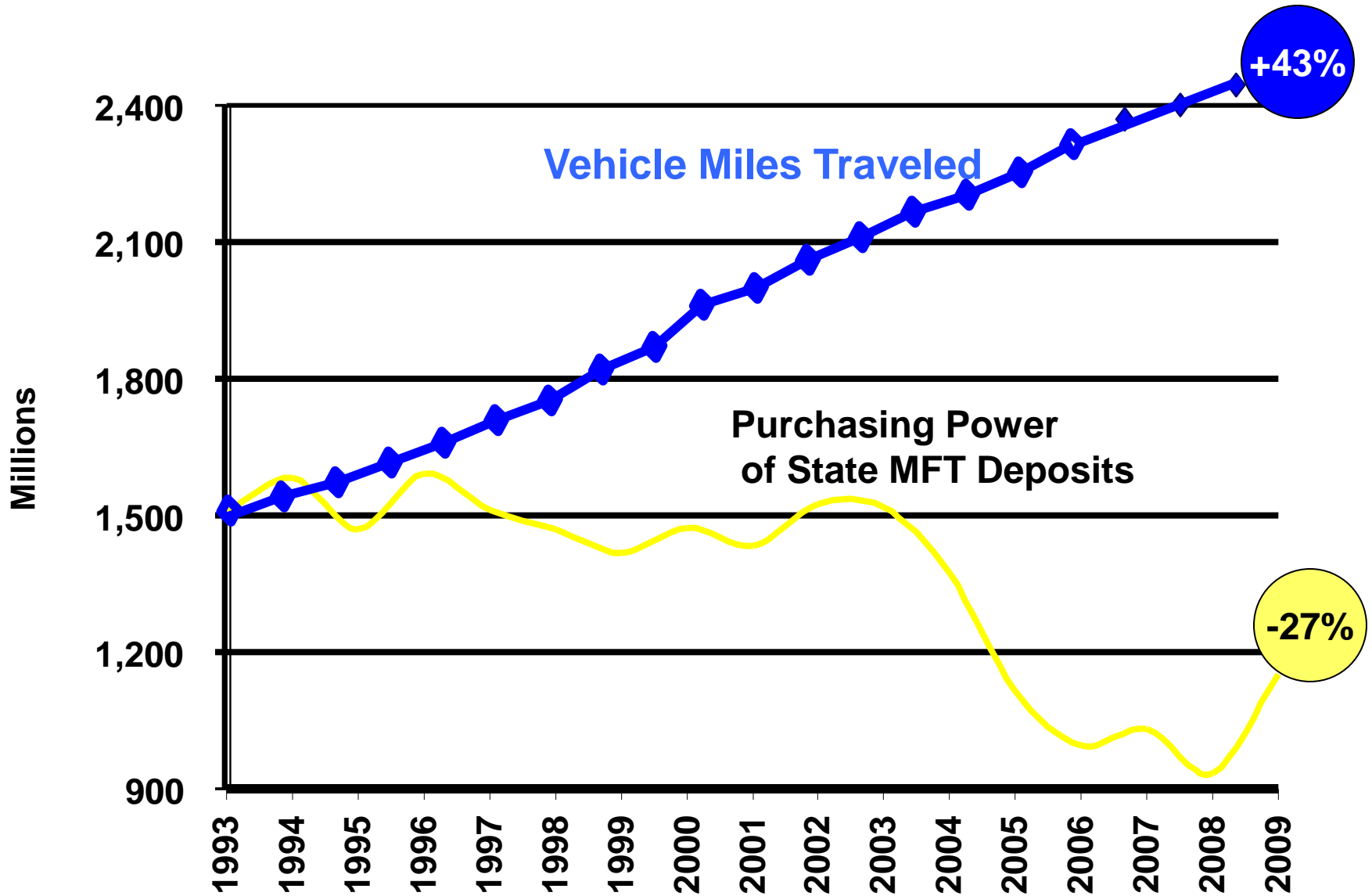
SUSTAINABLE TRENDS ?

**% Good
Or better**

\$ Millions



Needs vs. Financing



Sports Analogies

2009 – 2030 Time Horizon

Needs & encumbrances



A BASEBALL

LESS:

Revenues



A GOLF BALL

EQUALS:

Challenge



A TENNIS BALL

Stimulus funds

• **AN AIR-RIFLE BB**

MOBILITY CONSEQUENCES

The Texas Transportation Institute analysts estimate a **\$500 Billion cost to travelers** on Texas roads due to congestion delays through 2030 with current funding.

This would be due to the inability to add road capacity needed with an expected 60% increase in population.

\$41 Billion

The expected cumulative loss
in pavement condition
between 2010 and 2020.*

** Cost to restore to good condition,
if there were funds to do so.*



What to do ?.....

..... find more money..?



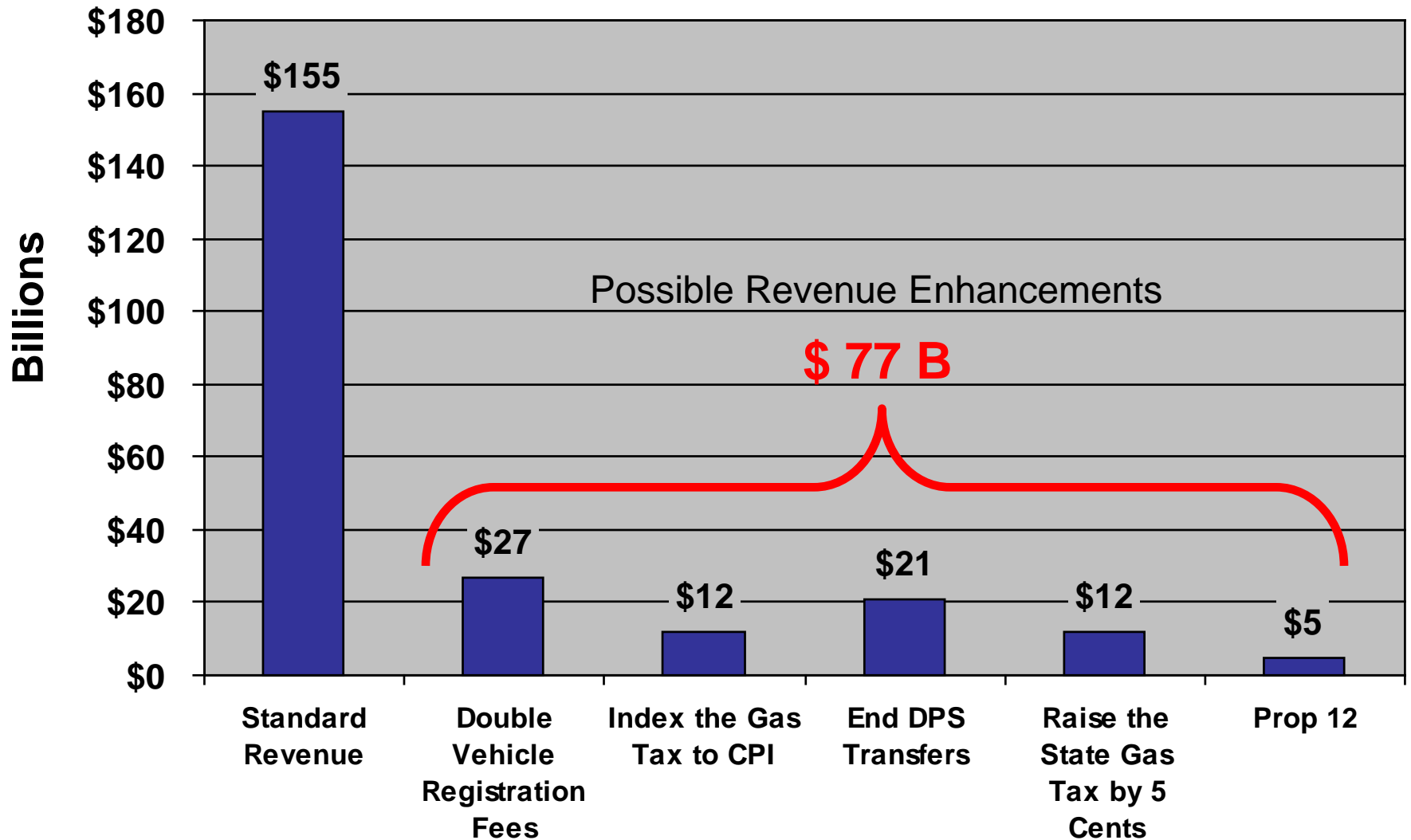
Possible revenue enhancements mentioned:

- Increase vehicle registration fee
- Index the gas tax to the CPI
- End DPS transfers
- Raise the state gas tax
- Fund Proposition 12 bonds



What does our TRENDS model say?

Estimates Of Possible Revenue Enhancements

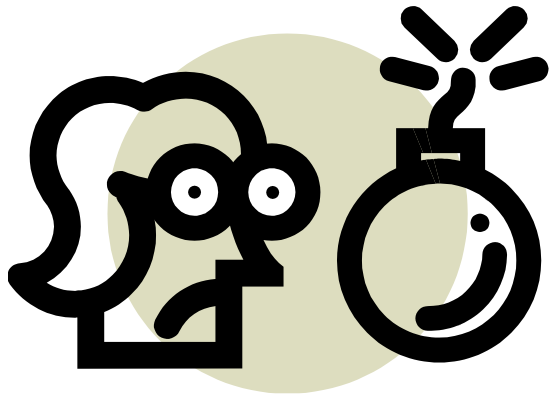


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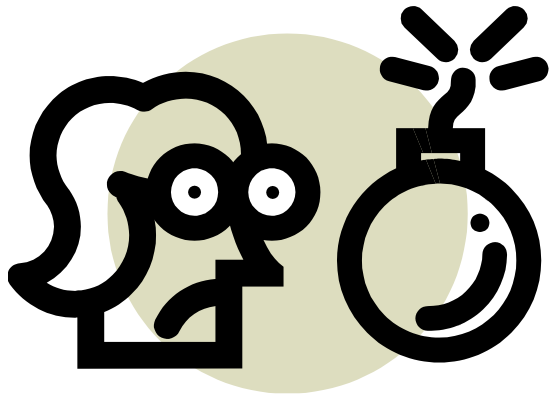
So...
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What else to do?

1. Improve internal efficiencies

2. Improve allocation methods



What else to do?

1. **Improve internal efficiencies:**

Organizational

(management audits, restructuring,
modernization initiative)

Operational – efficiency

(modernization initiative, operations
research projects,
Operational Excellence Office)

NORTH-HOLLAND

**PUBLIC SECTOR
EFFICIENCY
MEASUREMENT**

*Applications of
Data Envelopment Analysis*

J.A. GANLEY
J.S. CUBBIN



**Operations
Research**

**Determining Optimality &
Efficiency Assessment**

**Management
Science**

**Data Analysis,
Forecasting, &
Decision-Making Methods**

THOMAS H. DAVENPORT, JEANNE G. HARRIS
Coauthors of *Competing on Analytics*
and ROBERT MORISON

Analytics at Work

Smarter Decisions
Better Results



HARVARD BUSINESS PRESS



*Institute for Operations Research
and the Management Sciences*

- **50,000 INFORMS, ORSA, and TIMS conference presentations;**
- **bibliographic database provides access to over 39,000 journal bibliographic entries;**
- **Comprehensive guide to software, vendors, and publishers from our member magazine;**
- **contact data on all 9000 INFORMS members.**

The Roles of Stat & MS/OR

Basic statistical analysis can often provide adequate basis for making decisions.

But sometimes the number of choices and mathematical considerations require structured decision methods and software.

Data



Information



DECISION



Analytics

Statistical Analysis

**MS/OR*
Decision
Methods**

* Management Science / Operations Research

Current TxDOT Activities using OR methods:

1. Maintenance Section Location Optimization

- Analyzes tradeoff between section overhead cost and travel costs
- Identifies least-cost number and location of maintenance sections

2. RTI 5534 – Advance ROW Optimization Tool

- Identifies parcels most likely to escalate
- Identifies cost-effective purchases



3. RTI 6412 – Fleet Replacement Optimization

- Identifies least-cost vehicle replacement policies by vehicle type
- Best policies under budget constraint



Current TxDOT Activities using MS methods:

4. RTI 6655 – Pavement Preservation Optimization

- *Most beneficial condition goals within budget*
- *Optimization of maintenance scheduling*

5. RTI 6487 – Project Evaluation Tool (PET)

- *Best mobility option under multiple criteria*
- *Part of a larger effort to use benefit/cost analysis*

6. TRENDS Revenue Forecasting Model

- *Forecasts revenue available for construction*
- *Multiple inputs for “what-if” analyses*
- *A fleet efficiency technology forecast submodel*

Current TxDOT Activities using MS methods:

7. Maintenance Allocation Formula Advisory Group

- *Viewed from the various math disciplines*



8. Management Science Scoping Study

- *A MS/OR “audit”.*



9. Application of “Fair Division” methods

- *Can these methods be applied?*

RTI 5534 – Advance ROW Optimization Tool



Project Purpose: to develop a tool to find the economic balance between ROW advance purchase and ongoing project acceleration

The benefit of ROW advance-purchase is avoiding property price escalation.



The benefits of accelerating project completion are [1] avoiding highway construction cost inflation and [2] earlier delivery of benefits to travelers.

RTI 5534 – Advance ROW Optimization Tool

District	Number of Parcels	Difference in Mean Cost Due to Early Acquisition	Mean Cost of Early Acquisition	Saving/Cost Ratio	Early Acquisition Parcel ID
Austin	20	\$769,000	\$181,000	4.25	5TE
Dallas	10	\$44,653,000	\$16,781,000	2.66	9
El Paso	19	\$475,000	\$475,000	1.00	3
Houston	28	\$172,791,000	\$183,057,000	0.94	2

Project 0-6412: Equipment Replacement Optimization



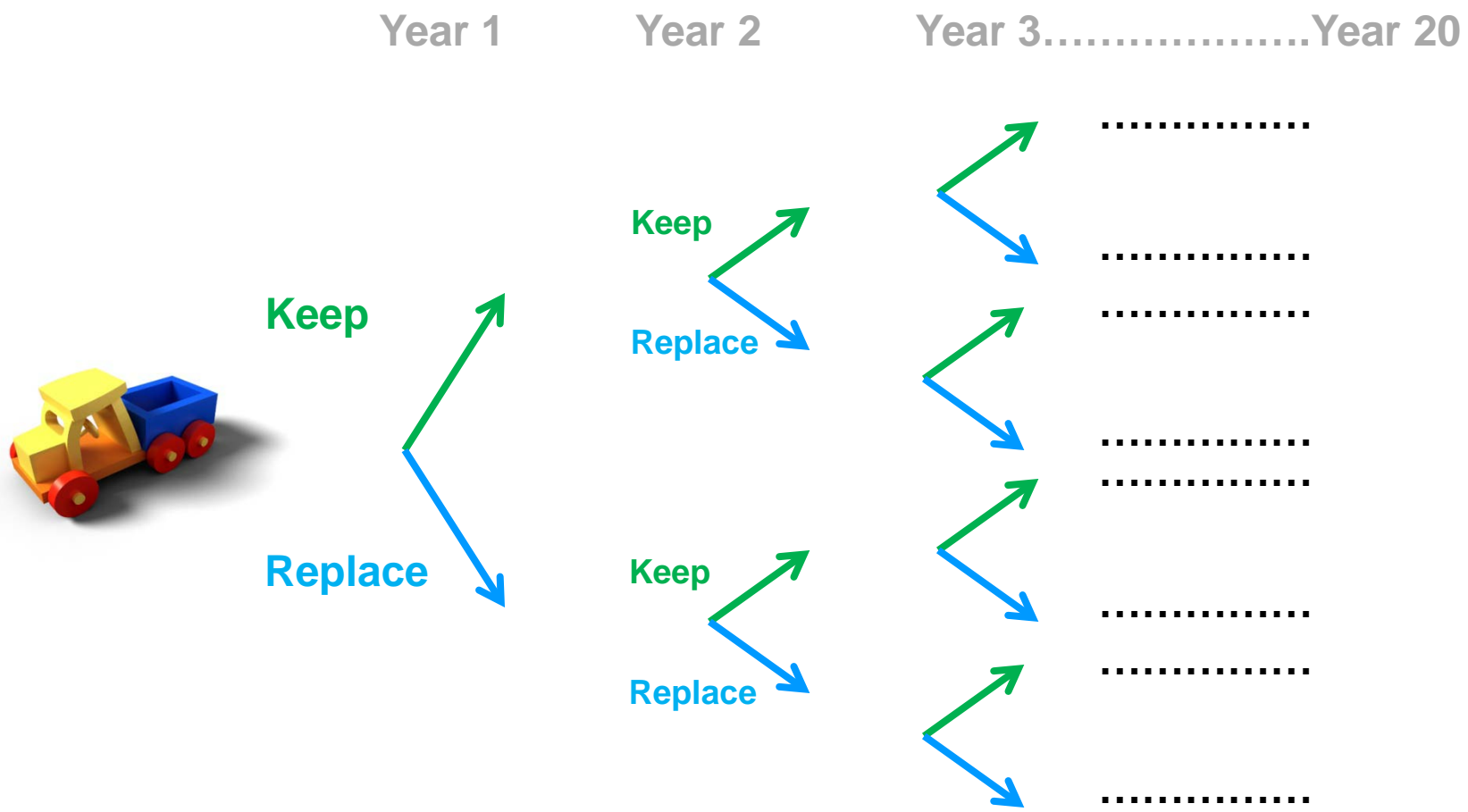
TxDOT fleet: 17,000 vehicles

Annual replacement budget: \$50,000,000

Estimated annual savings = \$2,500,000 - \$5,000,000

Project Purpose: to develop a tool to find the minimum-cost vehicle-class replacement policy which can be updated as parameters change over time.

Problem: What is the least-cost sequence of 200,000,000,000,000,000,000,000 *K-R* decisions ?



Solution Method: Dynamic Programming

RTI Project 0-6637

Management Science Applications for TxDOT - Scoping Study -

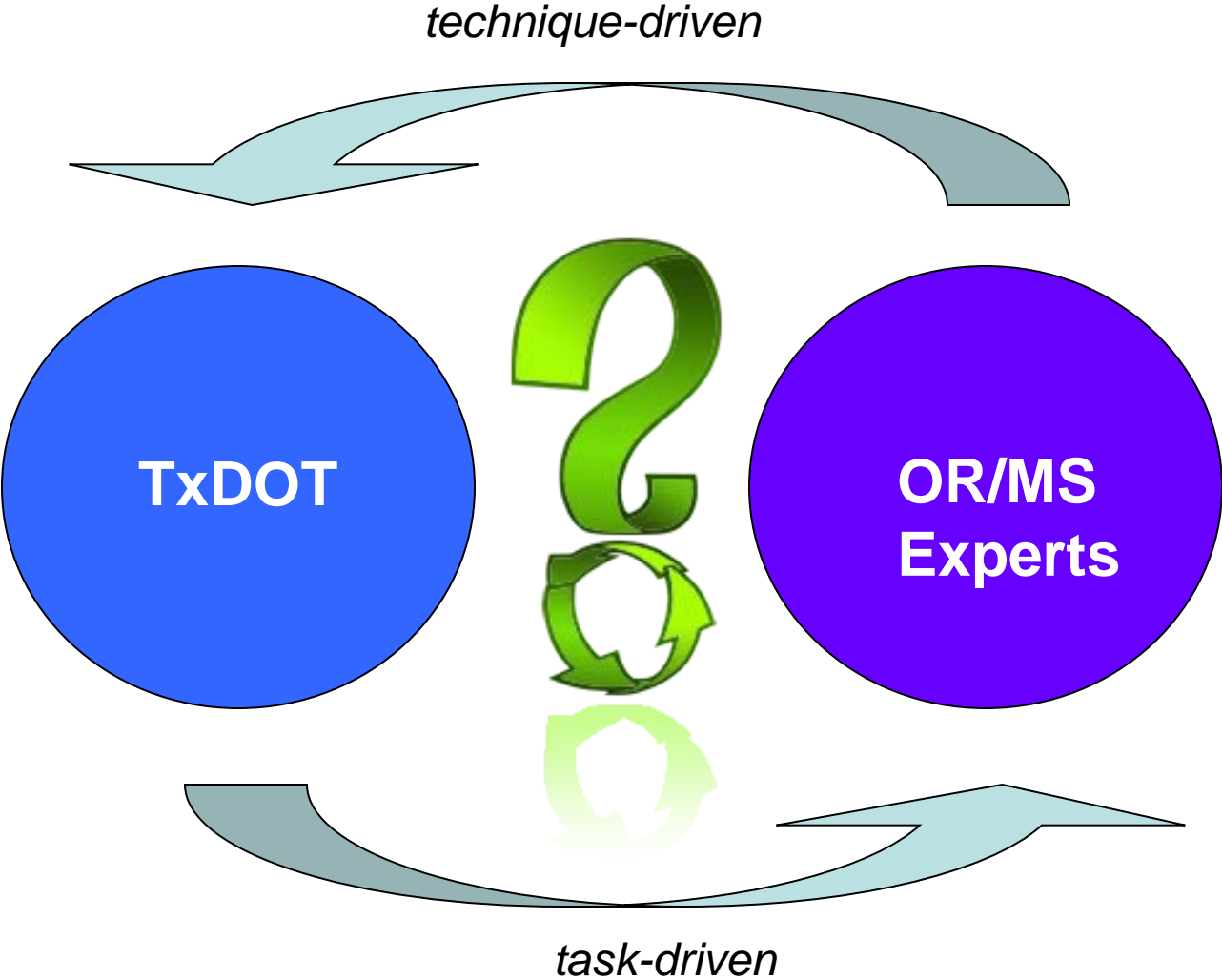


Project Purpose: to conduct a management science “audit”
– to examine TxDOT business decisions which are amenable to
improvement with MS/OR methods – generating problem
statements for in-depth research.

WHY THIS PROJECT ?

- 1. Many operational problems at TxDOT are not unique to TxDOT, or even to transportation – they are problems common to many industries.**
- 2. Only a small fraction of the universe of MS techniques have been applied to transportation.**
- 3. Many of the successful decision-support projects at TxDOT have been due to the right department person finding the right researcher at the right time for the right problem – ad-hoc – how to systematize?**

Process of mapping applications:



Examples of Identified Analytics Applications

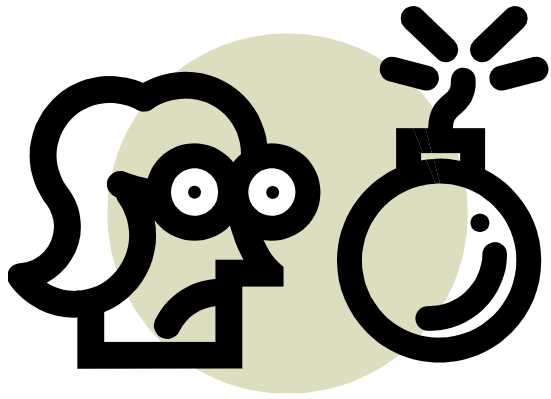
- **Forecasting** – revenue; traffic; asset condition
- **Multi-criteria prioritizing** – research projects; hiring
- **Location & scheduling optimization** – emergency response; fleet replacement; bridge & pavement management
- **Project Selection** – road capacity projects; bridge projects
- **Multiple-objective funds allocation** – MPO funds allocations; capacity vs. maintenance allocations
- **Life-cycle cost analysis** – asset management
- **Efficiency analysis** – maintenance sections

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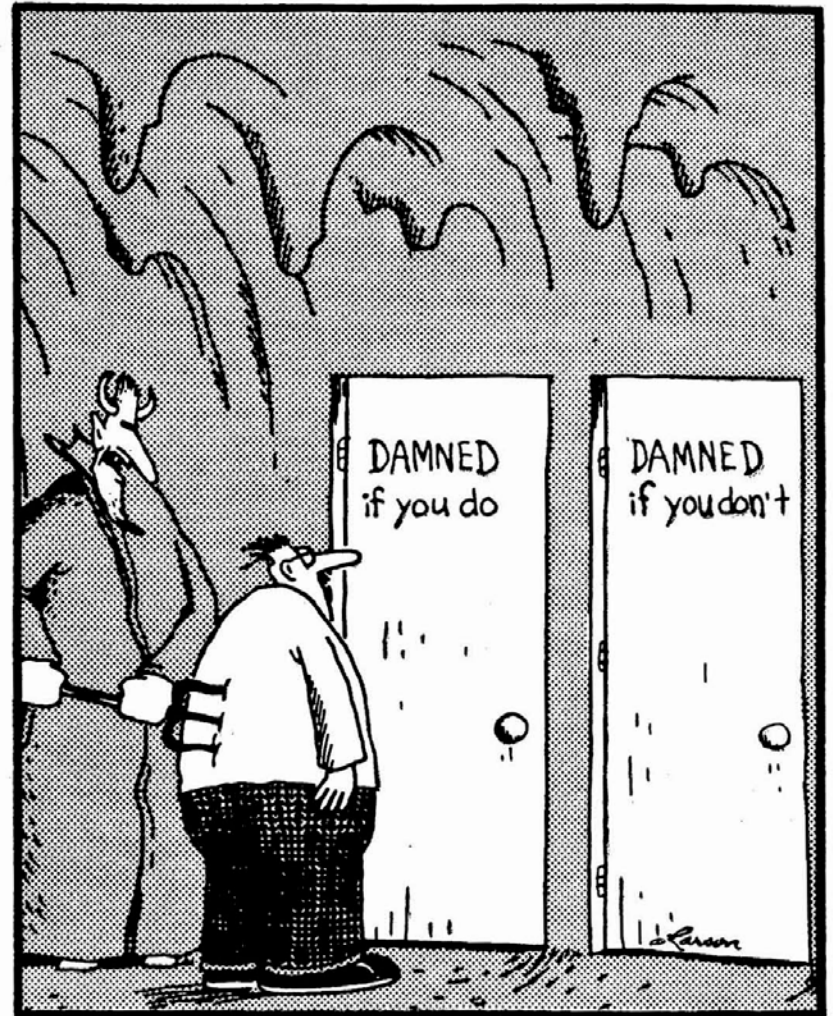
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What else to do?

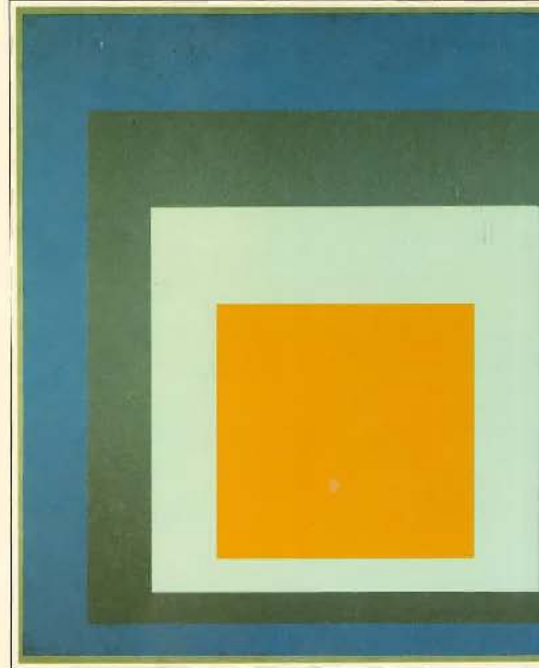
2. Improve allocation methods



"C'mon, c'mon—it's either one or the other."

Management Science

ANDREW W. SHC



Allocation Formula Advisory Project



Goal: To produce the best possible allocation formulas.

Mission: To employ the best available expertise to review and improve TxDOT maintenance funds allocation formulas, and incorporating input from transportation stakeholders.

Team: Texas Transportation Institute; Cambridge Systematics Inc.; expert panel; stakeholders; TxDOT Maintenance Division; and TxDOT Operational Excellence Office

Allocation Formula Advisory Project

Panel Selection Process:



When considering a system for allocating scarce transportation funds, there are **six basic criteria**:

1. Does this allocation produce the “**most bang for the buck**”?
2. Does this allocation consider **all relevant factors** of need?
3. Does this allocation make **economic** sense?
4. Do the formulas make **mathematical** sense (are they specified correctly)?
5. Does the allocation consider **fairness**?
6. Does the allocation consider **customer values**?

Corresponding Mathematical Disciplines

1. Optimization – *most bang for the buck*
2. Decision Analysis – *multiple considerations*
3. Macroeconomics – *“it’s the economy...”*
4. Econometrics – *getting the equations right*
5. Fair Division – *money is short*
6. Market Analysis – *knowing customer values*

STRATEGIC PRESCRIPTIONS FOR TXDOT

FROM

ANALYTICS: THE NEW PATH TO VALUE

**A Report of Findings from the 2010 New Intelligent Enterprise
Global Executive Study and Research Project
By IBM Analytics and the MIT Sloan School of Management**

IBM Global Business Services
Business Analytics and Optimization
Executive Report
Prepared For: Yvonne Howze
IBM Institute for Business Value

In collaboration with MIT Sloan Management Review

MIT Sloan
Management Review

Analytics: The new path to value

*How the smartest organizations are embedding analytics
to transform insights into action*



Findings from the 2014 Now-Intelligent Enterprise
Global Executive Study and Research Project

MIT Sloan
Management Review

**RESEARCH
REPORT**

FALL 2011

In collaboration with
IBM Institute for Business Value



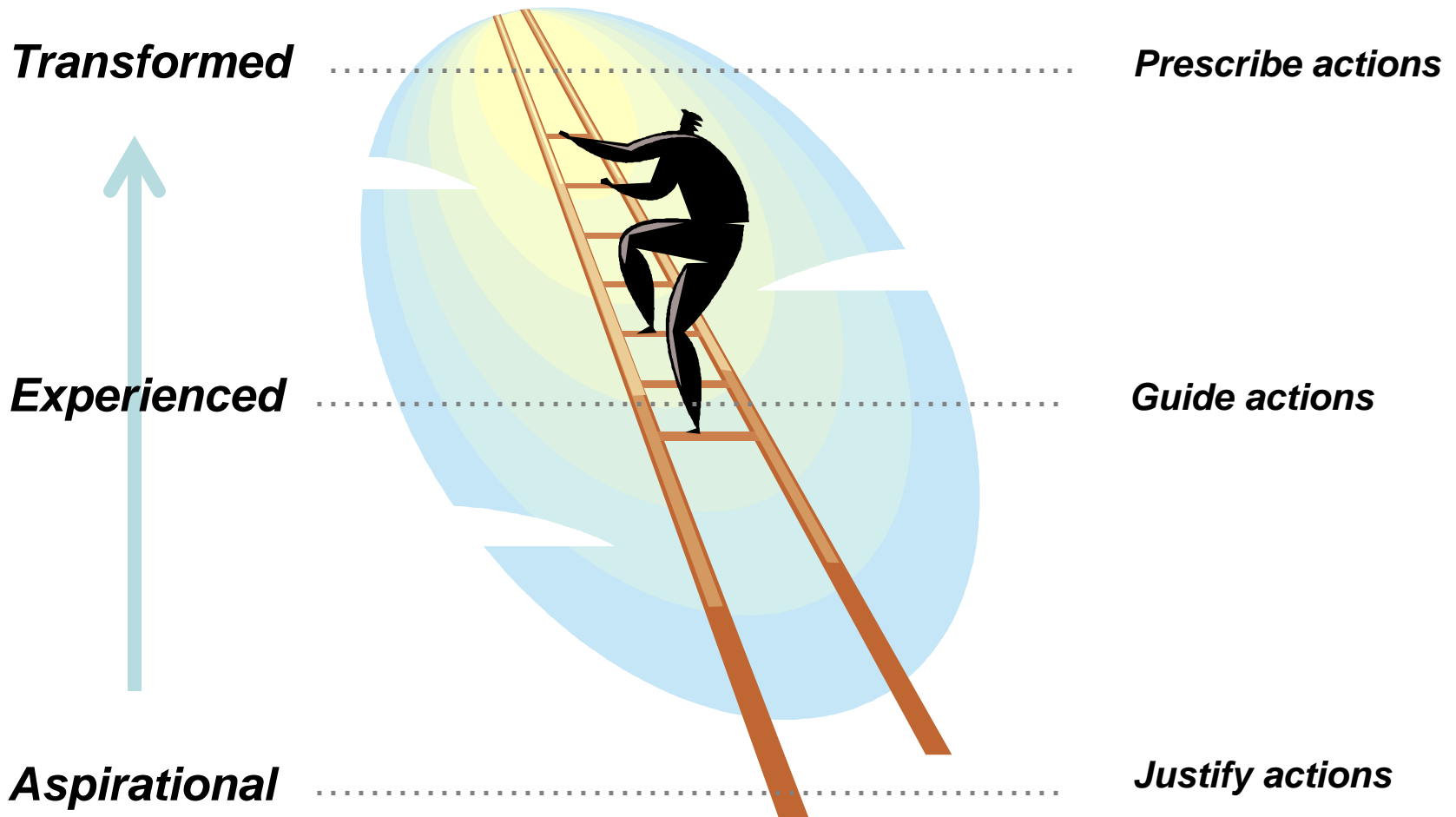
Analytics: **The** **Widening** **Divide**

How companies are achieving competitive
advantage through analytics

By David Kiron, Rebecca Shockley, Nina Kruschwitz, Glenn Finch
and Dr. Michael Haydock

Organizational Levels Of Analytics Capabilities

Analytics used to:



Organizational Analytics Capabilities

So what ???

Well...

A key finding of the MIT Sloan School study was that ***“top performing organizations use analytics five times more than lower performers.”***

-- Page 2, Figure 1
Analytics: the New Path to Value

RECOMMENDATION 1:

Focus on the biggest and highest value opportunities

TxDOT IMPLEMENTATION PRIORITIES:

1. Road maintenance optimization
2. Bridge maintenance optimization
3. Capacity project selection
4. Performance efficiency analysis
5. Workforce optimization

RECOMMENDATION 2:

Within each opportunity, start with questions, not data

KEY QUESTIONS FOR TXDOT:

1. Within a budget, what is the least life-cycle cost of maintaining which roads, given traveler values?
2. Ditto for bridges.
3. Which capacity investment projects bring the greatest rates of return, and how to account for equity considerations?
4. How to systematically assess operational efficiency?
5. How to optimize personnel placement and training?

RECOMMENDATION 3:

Embed insights to drive actions and deliver value

TRANSFORMING INSIGHTS INTO TXDOT ACTIONS:

- Determine what pro forma information is needed in dashboard form.
- Build pro forma dashboards linked to simulations of alternative scenarios.
- Quantify customer values and preferences in ways conducive to making decisions.

RECOMMENDATION 4:

Keep existing capabilities while adding new ones

TXDOT ACTIONS TO AUGMENT ANALYTICS:

- Provide training on basics of spreadsheet engineering, data analysis, and optimal visual presentation of quantitative data.
- Provide training on intermediate and advanced analytics.
- Establish an Analytics career ladder supported by appropriate training.
- Provide briefings on the utility of analytics to managers.

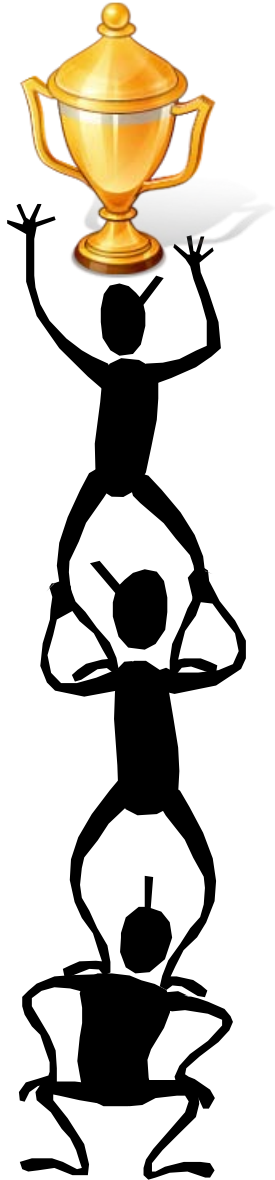
RECOMMENDATION 5:

Use an information agenda to plan for the future

A TXDOT INFORMATION AGENDA:

- Chief Information Officer reconfigures agency data systems to be integrated, consistent, and trustworthy.
- Align priority analytics activities to support strategic goals.
- Use a forward-looking information agenda to enable TxDOT to keep pace with advances in mathematical sciences and technology.

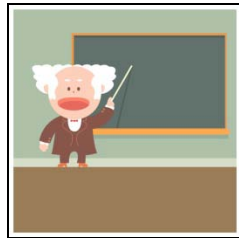
Becoming a Data-Driven DOT



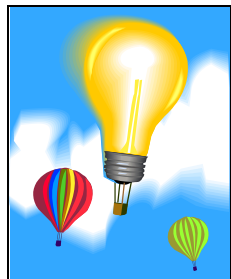
Strategic Elements:



Analytics Career Ladder



Analytics Training



Analytics Competency Center

Evolution of TxDOT Analytics



- Ad-hoc analytics projects



- Management Science Scoping Project



- Operational Excellence Office
- Analytics Strategic Plan
- In-house training
- Analytics career track

5 Signs You Could Benefit from OR/MS Analytics

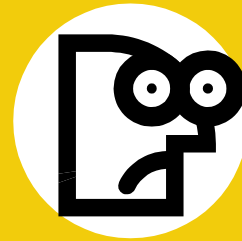
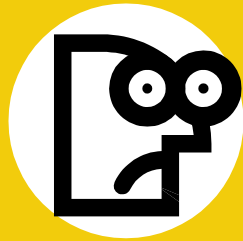
You face complex decisions. Are you faced with more decision factors than you can get your arms around? Do your key operational computer systems lack intelligence? O.R. professionals can analyze complex situations and build intelligence into key systems, revealing the best options. But before you act, talk with an O.R. professional to confirm that taking an O.R. approach will pay dividends.

You're having problems with processes. One or more of your processes is broken or needs to work a lot better. Many small, day-to-day decisions are not being made well, and it's having an impact on your bottom line. O.R. can help improve these processes and their outcomes dramatically.

You're troubled by risk. Do you want to limit or reduce risk? Assessing the risk of a new project or contract can be tricky. O.R. can help you quantify risk, which is key to controlling it. O.R. can assist you in planning how best to balance risk against the gains you expect.

Your organization is not making the most of its data. Do you track information about your organization and have data that is begging to be used for decision making? O.R. specializes in working with data – extracting the most valuable information from what's currently collected, and showing what additional data you could collect to increase the value even further.

You are extremely resource-limited. An O.R. professional can help you stay on top with the latest methods – and open up important new sources of advantage.



It's QUESTION TIME!!