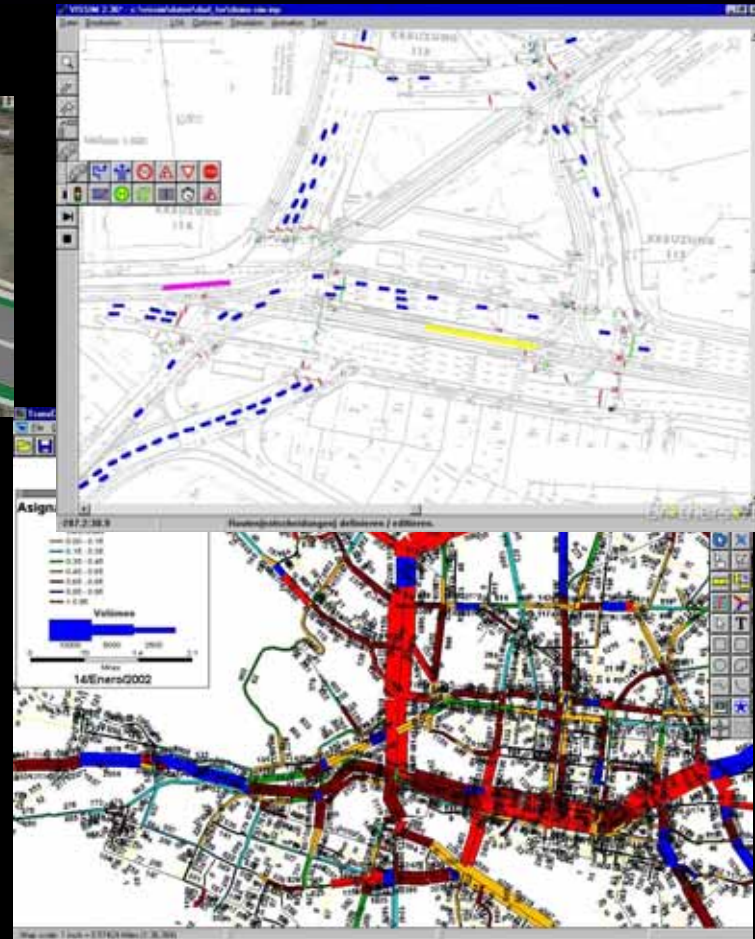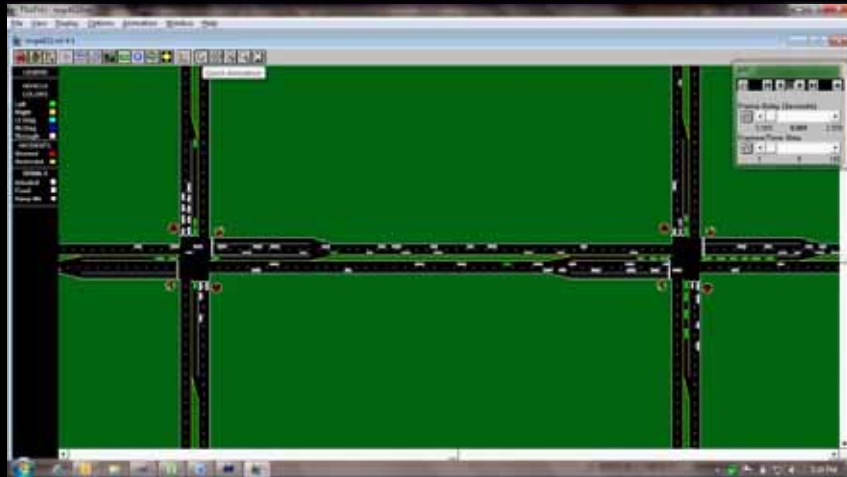# Beyond Animation:
Interactive Visualization Techniques for Big Transportation Data

Michael L. Pack
Univ. of Maryland CATT Laboratory

Traditional Modeling & Simulation Outputs

Things we all care about

- Solving problems

- Analyzing data

- See what we study actually get used by others!

# Things we all NEED to care MORE about

- Showcasing our work to others
- Getting people excited about our work
- Getting people who have the power to fund our work willing to fund MORE of our work!

- COMMUNICATING RESULTS!

Changing our mindset

- Is an animation always appropriate?
- What other options do I have?
- Should this be difficult?
- Do we have the tools we need?

- **Goal:**
  "Effectively communicating our results
   to get better results."
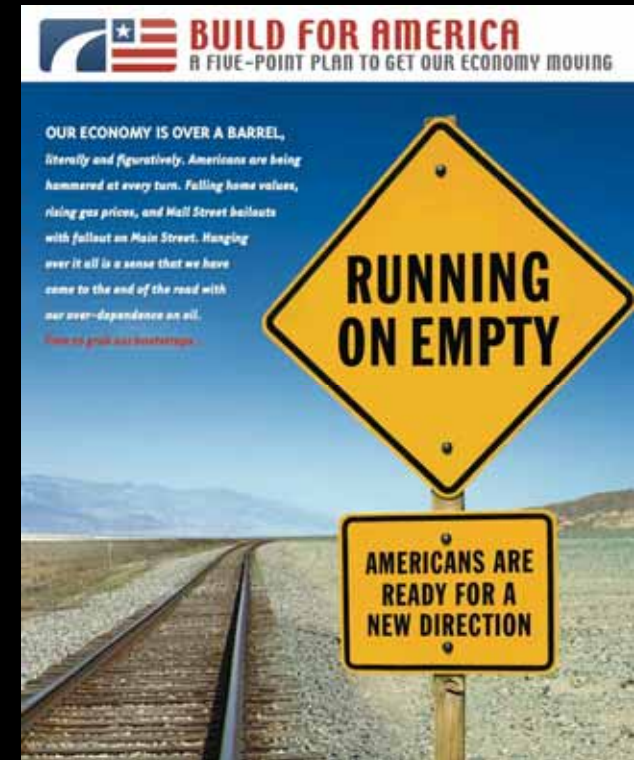
How much data are we getting today?

- RITIS Today
  - Traffic events: 40,000 records per day: 0.001 Gb/day
  - Traffic detectors: 35,000,000 records per day: 5 Gb/day
  - Probe vehicle data: 4,200,000,000 records per day: 550 Gb/day
  - CCTV, weather, radio, etc: NO,STA,TSK,EPT records per day: ??? Tb/day
  - V2X & Automation data: ?,???,???,???,??? records per day: ??? ?b/day

| EVENT | DETECTOR | PROBE | CONNECTED VEHICLE |
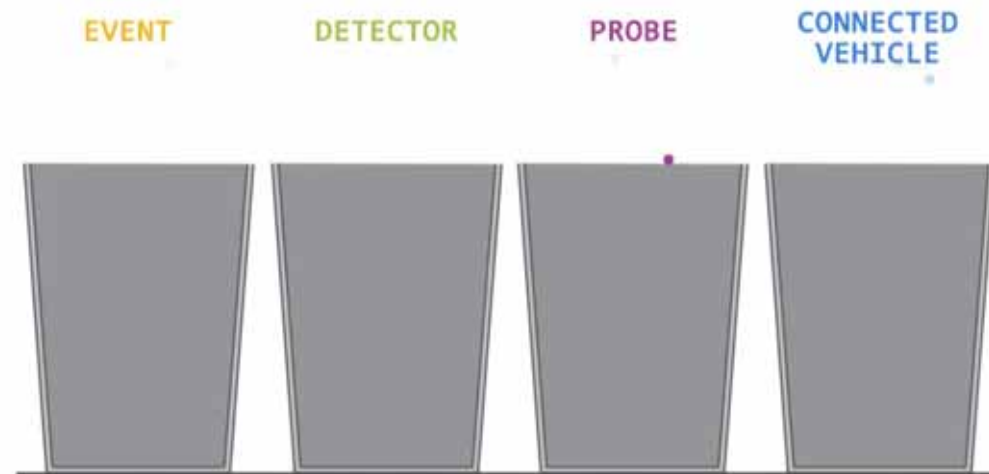
Our Challenge

- Our mission is to make ALL of this data
  - **easily accessible,**
  - **usable, and**
  - **understandable**

  to end users and ITS applications...
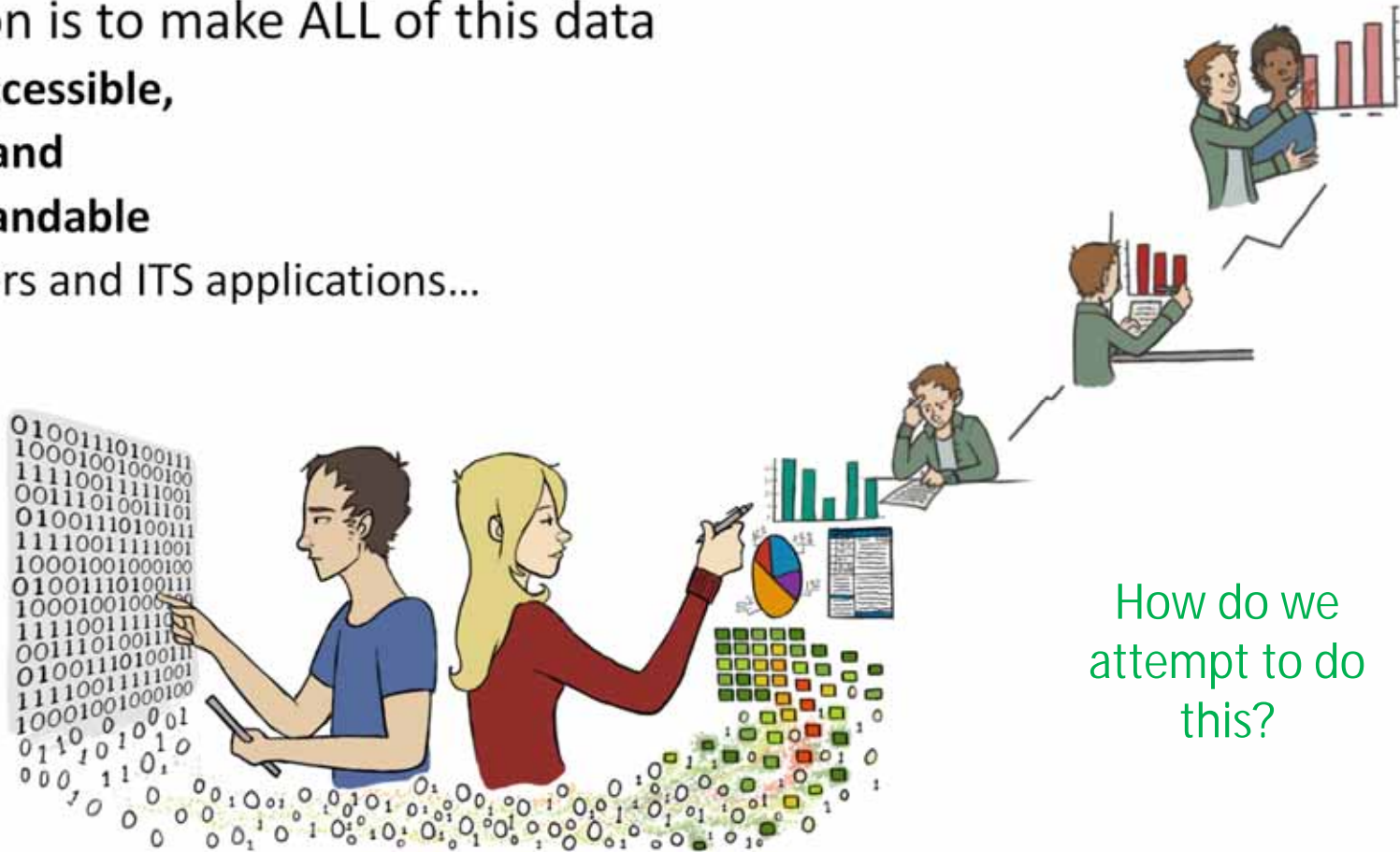
How do we attempt to do this?

7

Visual Analytics

- Not just about pics and graphs...
- Traditional querying (or analysis) demands that you
  - Know what question to ask
  - know how to ask it (SQL or other language)

- Visual Analytics provide the freedom to:
  - Explore data in new ways
  - Ask meaningful questions that you wouldn't have normally thought to ask
  - Develop new hypothesis
  - and realize new solutions

Why Visualization?

- **Visual bandwidth is enormous**
  - Human perceptual skills are remarkable
    - Trend, cluster, gap, outlier...
    - Color, size, shape, proximity...
  - Human image storage is fast and vast

An Experiment:

On the next slide, tell me the 3 countries with the largest values beside them.
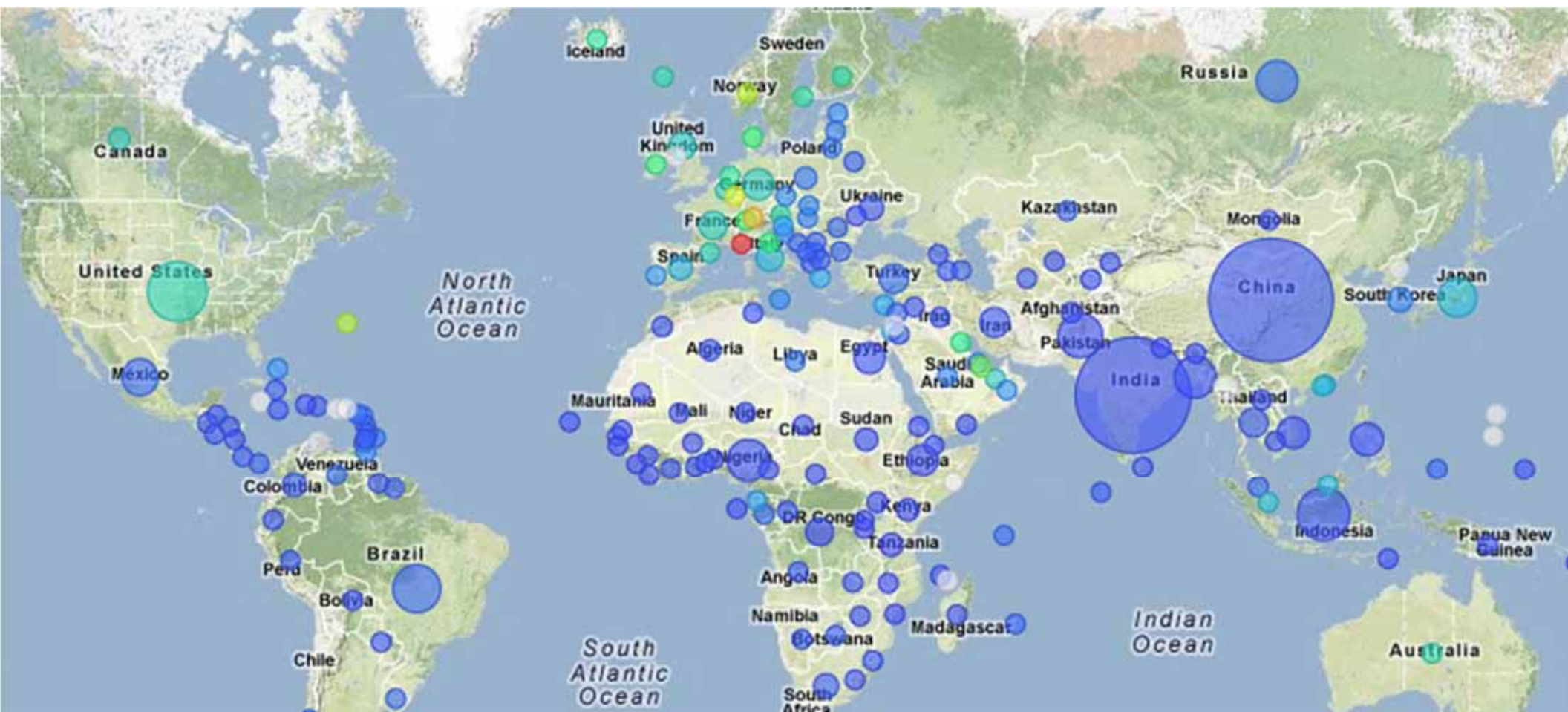
You have 3-seconds.

	Road deaths per 100,000 population	Population (millions)	Road deaths
Australia	**8.0**	**20.3**	**1,627**
Austria	9.3	8.2	768
Belgium	10.4	10.4	1,089
Canada	9.1	32.3	2,925
Czech Republic	12.6	10.2	1,286
Denmark	6.1	5.4	331
Finland	7.2	5.2	379
France	8.8	60.6	5,318
Germany	6.5	82.5	5,361
Great Britain	5.5	58.5	3,201
Greece	15.0	11.1	1,658
Hungary	12.7	10.1	1,278
Iceland	6.3	0.3	19
Ireland	9.5	4.2	396
Italy	-	-	-
Japan	6.2	127.8	7,931
Luxembourg	-	-	-
Netherlands	4.6	16.3	750
New Zealand	9.9	4.1	405
Norway	4.9	4.6	224
Poland	14.3	38.2	5,444
Portugal	11.8	10.6	1,247
Slovakia	-	-	-
Slovenia	12.9	2.0	258
South Korea	13.2	48.3	6,376
Spain	10.2	43.5	4,442
Sweden	4.9	9.0	440
Switzerland	5.5	7.4	409
Turkey	-	-	-
United States of America	14.7	295.4	43,443
OECD median	**9.5**		

What did you see?

Same Experiment:

On the next slide, find me the 3 countries with the largest values over them.

You have 3-seconds.

Iceland
Sweden
Norway
United Kingdom
Poland
Germany
France
Spain
Italy
Ukraine
Russia
Kazakhstan
Mongolia
Turkey
Iraq
Iran
Afghanistan
Pakistan
China
South Korea
Japan
Canada
United States
México
North Atlantic Ocean
Algeria
Libya
Egypt
Saudi Arabia
India
Thailand
Mauritania
Mali
Niger
Chad
Sudan
Ethiopia
Venezuela
Colombia
Nigeria
DR Congo
Kenya
Tanzania
Indonesia
Papua New Guinea
Peru
Brazil
Bolivia
Angola
Namibia
Botswana
Madagascar
Indian Ocean
Chile
South Atlantic Ocean
South Africa
Australia

What did you see?

Our process & our "Design Mantra"
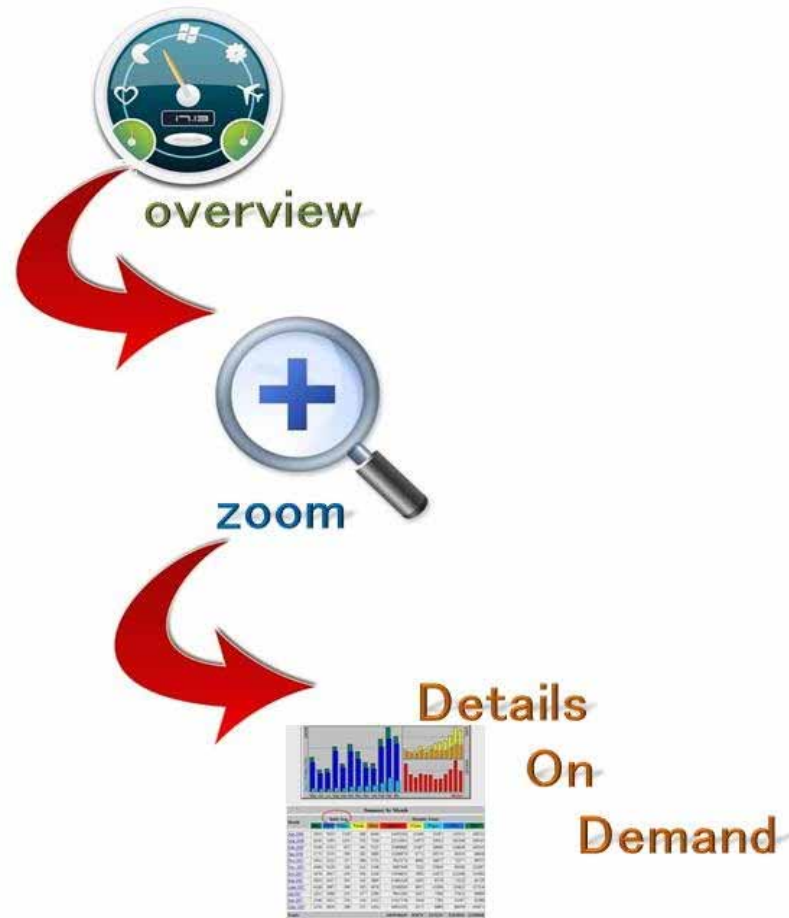
Who is your audience?

- Engineers
- Planners
- Operators

Vs.

- Legislators
- Media
- Decision Makers
- Public

Examples

Vehicle Type: All **Display:** Total cost

Total Cost

	12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	Daily Totals
12/01/14	$0K	$0K	$0K	$0K	$0K	$0.5K	$17.7K	$34.1K	$50.7K	$8.9K	$0.3K	$0.2K	$0.3K	$0.6K	$3.1K	$11.3K	$31.8K	$69.1K	$48.3K	$10.9K	$0.9K	$0.5K	$0.2K	$0.2K	$289.6K
12/02/14	$0K	$0.1K	$0K	$0K	$0.1K	$2.4K	$36.2K	$43.5K	$49.1K	$23.1K	$5.6K	$12K	$1.6K	$2.1K	$8K	$15.9K	$49.2K	$82.4K	$48.1K	$5.3K	$1.6K	$1.6K	$0.9K	$0.2K	$389K
12/03/14	$0.1K	$0K	$0K	$0K	$0.1K	$1K	$20.4K	$40.6K	$33.3K	$16.1K	$2.0K	$0.6K	$0.5K	$1.4K	$4.5K	$12.1K	$33.7K	$56.7K	$27.3K	$3.5K	$0.7K	$0.5K	$0.2K	$0.1K	$256.1K
12/04/14	$0K	$0K	$0K	$0.1K	$0K	$0.5K	$17.6K	$35K	$29K	$8.4K	$1.2K	$0.7K	$0.5K	$0.5K	$8.1K	$18.7K	$32.9K	$58.8K	$41.4K	$1.8K	$0.6K	$0.4K	$0.2K	$0.1K	$256.4K
12/05/14	$0.2K	$0K	$0K	$0K	$0K	$0.2K	$5.2K	$27.3K	$22K	$6.1K	$1.1K	$3.3K	$2.9K	$8.8K	$13.4K	$42.4K	$66.4K	$61.6K	$25.9K	$5.4K	$2.1K	$0.5K	$0.5K	$0.8K	$296K
12/06/14	$0.5K	$0.1K	$0K	$0K	$0.1K	$0.1K	$0.1K	$0.1K	$0.4K	$0.2K	$0.6K	$2.0K	$11.9K	$10.7K	$12.4K	$10.6K	$14.7K	$7.5K	$2.6K	$1.4K	$1.7K	$1.1K	$0.0K		$80.7K
12/07/14	$0.2K	$0.1K	$0.1K	$0K	$0K	$0.1K	$0.1K	$0.1K	$0K	$0.1K	$0.2K	$0.6K	$0.2K	$0.3K	$2.9K	$2.4K	$9.4K	$6.2K	$1.4K	$2.2K	$0.4K	$0.3K	$0.2K	$0.2K	$27.5K
12/08/14	$0K	$0K	$0K	$0K	$0.1K	$0.4K	$12.7K	$26K	$21.9K	$5K	$0.5K	$0.5K	$1.1K	$0.6K	$3K	$10.2K	$23K	$27.7K	$15.2K	$1.1K	$1.3K	$0.4K	$0.2K	$0.1K	$150.9K
12/09/14	$0.1K	$0.1K	$0.1K	$0.1K	$0.1K	$1.1K	$26.2K	$47.5K	$51.9K	$35.8K	$13.5K	$1.8K	$5.1K	$2K	$6.8K	$16.4K	$43.3K	$63.5K						$0K	$354.3K
12/10/14	$0.1K	$0.1K	$0.1K	$0K	$0K	$0.3K	$13.4K	$37.7K	$31.5K	$12.1K	$1.1K	$0.3K	$0.2K	$10.4K	$7.1K	$40.7K	$48.3K						$0.1K		$297.9K
12/11/14	$0.1K	$0K	$0K	$0K	$0K	$0.7K	$19.7K	$35.6K	$37.5K	$13.3K	$3.6K	$0.6K	$0.5K	$2.4K	$12.8K	$29.8K	$37.1K	$32.7K				$0.3K		$0K	$236K
12/12/14	$0.1K	$0.1K	$0K	$0K	$0K	$0.4K	$23.5K	$32.9K	$18.5K	$5.4K	$3.1K	$1.7K	$3.8K	$6.4K	$12.6K	$29.4K	$41.5K	$37.8K			$0.2K		$0.2K		$256K
12/13/14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$2K	$11.1K		$9.2K	$0.1K				$0K		$0.6K		$50.9K
12/14/14	$0.1K	$0.1K	$0.1K	$0K	$0K	$0.1K	$0.1K	$0K	$0.1K	$0.2K	$0.2K	$0.1K	$0.3K	$1K	$1.9K	$1.9K					$0.1K		$0.3K		$9.1K
12/15/14	$0K	$0K	$0.1K	$0K	$0K	$0.5K	$16.7K	$33.6K	$27.4K	$6.2K	$0.2K	$0.6K	$6.6K	$28.1K	$30.9K	$19.7K	$31.8K	$48.3K				$0.4K		$0.1K	$283.2K
12/16/14	$0K	$0K	$0K	$0K	$0K	$0.6K	$11.5K	$26.5K	$40.6K	$18.3K	$5.3K	$8.5K	$12.5K	$6.4K	$10.3K	$21.5K	$54.6K	$57.5K				$0.2K		$0.1K	$301.7K
12/17/14	$0K	$0K	$0K	$0K	$0K	$0.3K	$13.6K	$37.9K	$26.2K	$11.3K	$6K	$4.7K		$3.1K	$8.2K	$16.4K	$55K	$61.5K	$41.9K		$3.3K	$1.4K	$0.2K	$0.1K	$303.8K
Hourly Totals	$1.6K	$1K	$0.6K	$0.5K	$0.6K	$9.2K	$238.5K	$458.2K	$439.6K	$172.7K	$44.7K	$36.9K							$68.2K	$15.9K	$9K	$9.2K	$4K		Grand Total $3,859,177.94

⬇ Export to Excel

Tuesday, December 9, 2014 5:00 PM
Delay cost:
  Total: $63,510.48
  Per vehicle: $0.38
  Per person: $0.32
Hours of delay:
  Person-hours: 2014h 13m 12s
  Vehicle-hours: 1696h 11m 7s
  Per vehicle: 36s
Volume:
  Total: 168,319 vph
  Passenger: 126,239 vph
  Commercial: 42,080 vph
Data validity: 100%
Click the table cell to see links to congestion scans

Want to know how the user delay cost is calculated? Read more in our documentation.

Notes
- The values in the 'Total cost' display mode are rounded to the nearest hundredth and displayed in thousands when values larger than $1K exist.
- The range of values for the colored backgrounds of each cell are based on the data of the selected display mode.
- Delay metrics are displayed for every hour of every day within the selected time range.
- The totals for every hour are shown in the bottom row while the totals for every day are shown in the rightmost column.
- The grand total for the entire time period is shown as the actual value and displayed at the bottom right corner.
- Volumes shown for each hour are summed across all road segments.

Legend

Weekdays: Lowest — Highest   Weekends: Lowest — Highest   No data

Visualizing changes in Congestion
(and other things)
over time with

TreeVersity

The StemView

Actual Change (Color)
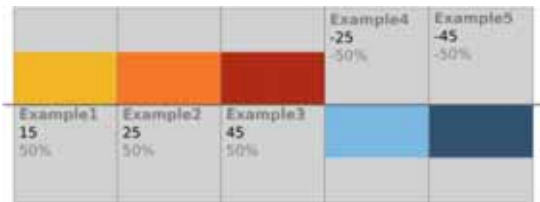
Relative Change (Height)

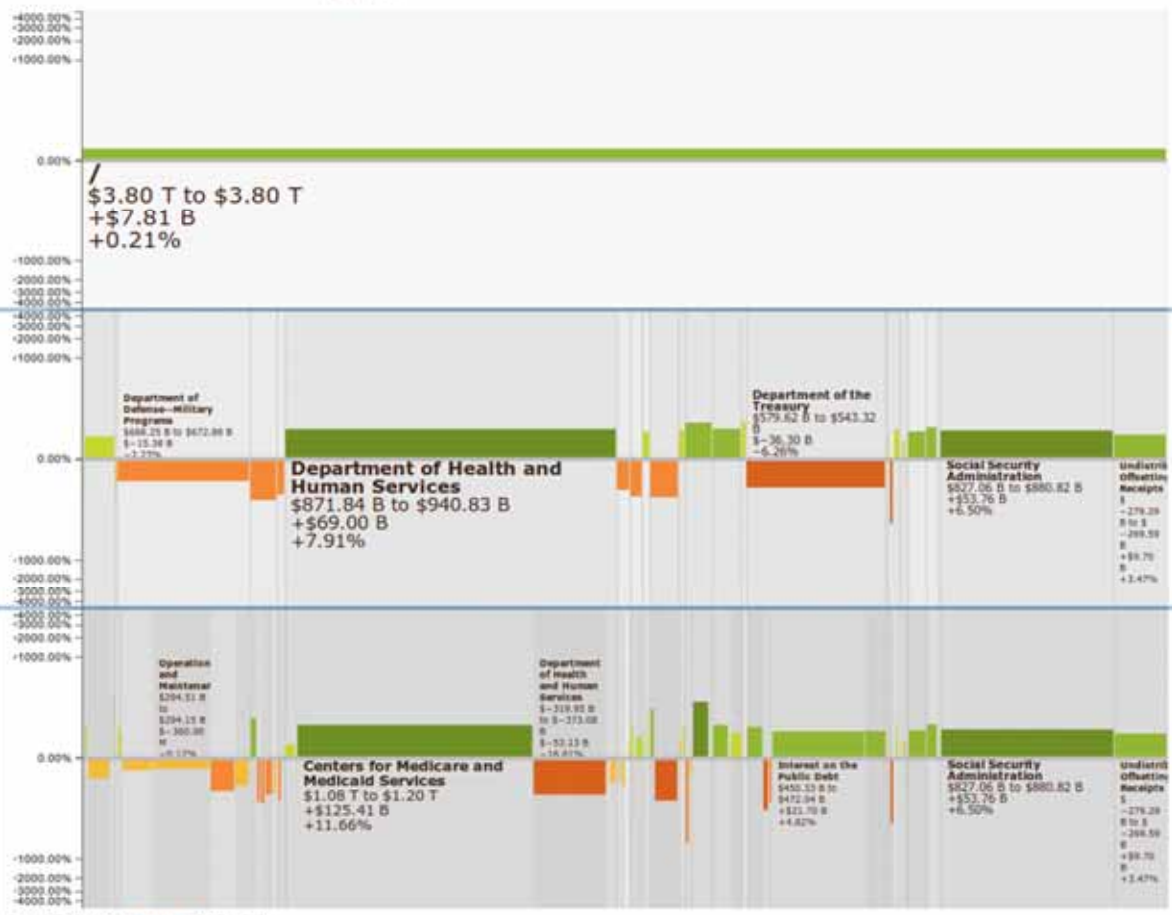## Ending Value (Width)

Direction

Created node

Removed node

Timelines | Node Details

budge ▾ | by: | year ▾ | ← | → | 📈 | 📊
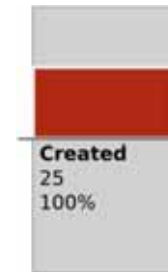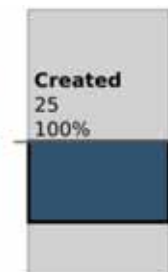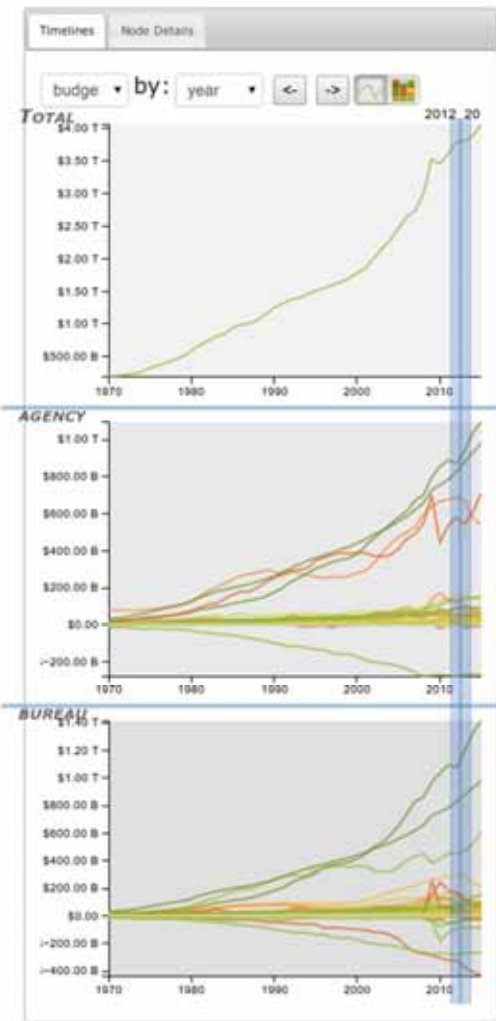
US Federal Budget

Comparing 2012 to 2013 🖼 🔀

$3.80 T to $3.80 T
+$7.81 B
+0.21%

Department of Health and Human Services
$871.84 B to $940.83 B
+$69.00 B
+7.91%

Department of Defense—Military Programs
$688.23 B to $672.90 B
$−15.34 B
−2.23%

Department of the Treasury
$579.62 B to $543.32 B
$−36.30 B
−6.26%

Social Security Administration
$827.06 B to $880.82 B
+$53.76 B
+6.50%

Undistributed Offsetting Receipts
$−279.29 B to $−269.59 B
+$9.70 B
+3.47%

Centers for Medicare and Medicaid Services
$1.08 T to $1.20 T
+$125.41 B
+11.66%

Operation and Maintenance
$204.51 B to $204.15 B
$−360.00 M
−0.17%

Department of Health and Human Services
$−319.93 B to $−373.08 B
$−53.15 B
−16.61%

Interest on the Public Debt
$450.53 B to $472.94 B
+$22.70 B
+4.82%

Social Security Administration
$827.06 B to $880.82 B
+$53.76 B
+6.50%

Undistributed Offsetting Receipts
$−279.29 B to $−269.59 B
+$9.70 B
+3.47%

Showing 474 nodes. Show all ☑ Show labels

Controls

▾ Legend

Color by:

budget ▾ | Difference ▾ | ☑4rt?

+$554.23 B to +$777.80 B
+$329.96 B to +$547.99 B
+$33.99 B to +$127.02 B
+$34.45 B to +$332.91 B
+$57.92 M to +$34.22 B
$−49.36 M to +$549.36 M
$−57.92 M to $−6.22 B
$−6.45 B to $−32.91 B
$−32.99 B to $−127.02 B
$−129.96 B to $−347.99 B
$−554.23 B to $−777.80 B

Height by:

budget ▾ | Percentage ▾ | ☑4rt?

Sort by:

Name ▾

Width by:

budget ▾ | Ending Val ▾

Border Color:

Removed
Created

+ What changed?

+ Hierarchy

+ Filters

The Reporting tool

Timelines | Node Details

budge ▾ by: year ▾

US Federal Bu
Comparing 201

Controls

What changed?

Topology

457 nodes were on both

8 nodes were removed

9 nodes were created

Absolute overall change

145 nodes decreased more than $−14.00 M

124 nodes increased more than +$11.00 M

Relative overall change

114 nodes decreased more than −10.73%

90 nodes increased more than +9.84%

Absolute change by Level

43 agency decreased more than $−1.00 M

182 agency didn't change

103 bureau decreased more than $−29.00 M

77 bureau increased more than +$23.00 M

Relative change by Level

42 agency decreased more than −0.93%

183 agency didn't change

65 bureau decreased more than −21.43%

39 bureau increased more than +18.50%

What changed?

Topology

457 nodes were on both

8 nodes were removed

9 nodes were created

Absolute overall change

145 nodes decreased more than $−14.00 M

124 nodes increased more than +$11.00 M

Relative overall change

114 nodes decreased more than −10.73%

90 nodes increased more than +9.84%

Absolute change by Level

43 agency decreased more than $−1.00 M

182 agency didn't change

103 bureau decreased more than $−29.00 M

77 bureau increased more than +$23.00 M

Relative change by Level

42 agency decreased more than −0.93%

183 agency didn't change

65 bureau decreased more than −21.43%

39 bureau increased more than +18.50%

$3.80 T to
+$7.81 B
+0.21%

TOTAL   AGENCY   BUREAU

Showing 474 nodes. Show all Show labels

▼ Filters:

☑ **Absolute Difference** ☑ +/-

+/-10.00 to: **+/-31.40**

☑ **Relative Difference** ☐ +/-

−20.00% to: **+120.86%**

☑ **Starting Val** ☑ +/-

+/-50.00 to: **+/-285.00**

☑ **Ending Val** ☐ +/-

−292.10 to: **−50.45**

TreeVersity2   Datasets ▾   Videos   About   Login   CATT HCIL

Timelines   Node Details

averar ▾ by: month ▾ [<-] [->] 📈 📊
Mar 2010   Apr 2010

350.00
300.00
250.00
200.00
150.00
100.00
50.00
2010 April July October 2011 April July October

5.50 K
5.00 K
4.50 K
4.00 K
3.50 K
3.00 K
2.50 K
2.00 K
1.50 K
1.00 K
500.00
2010 April July October 2011 April July October
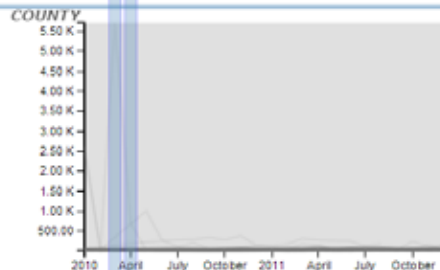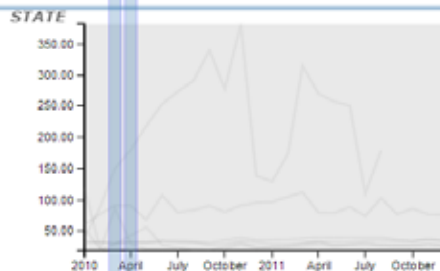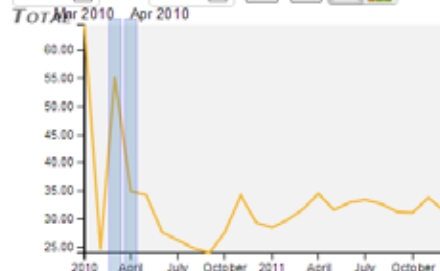
Traffic Bottlenecks

Comparing Mar 2010 to Apr 2010

NC
87.15 to 30.50
−56.65
−65.01%

HAYWOOD
5.72 K to 696.21
−5.02 K
−87.83%
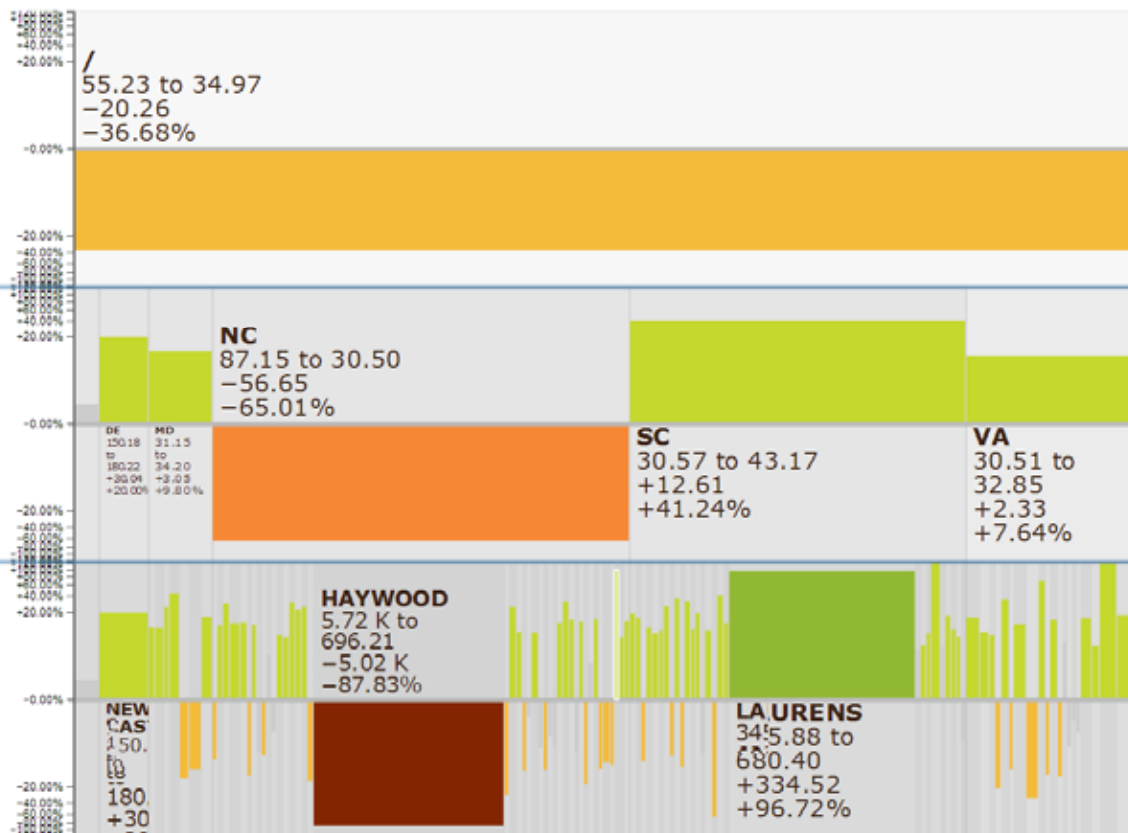
Showing 107 nodes. Show all ☑ Show labels

Controls

▸ Legend

▾ What changed?

Topology

106 nodes were on both

1 node was created

Absolute overall change

5 nodes decreased more than −20.26

9 nodes increased more than +11.08

Relative overall change

4 nodes decreased more than −36.68%

5 nodes increased more than +69.85%

Absolute change by Level

1 state decreased more than −56.65

2 state increased more than +12.61
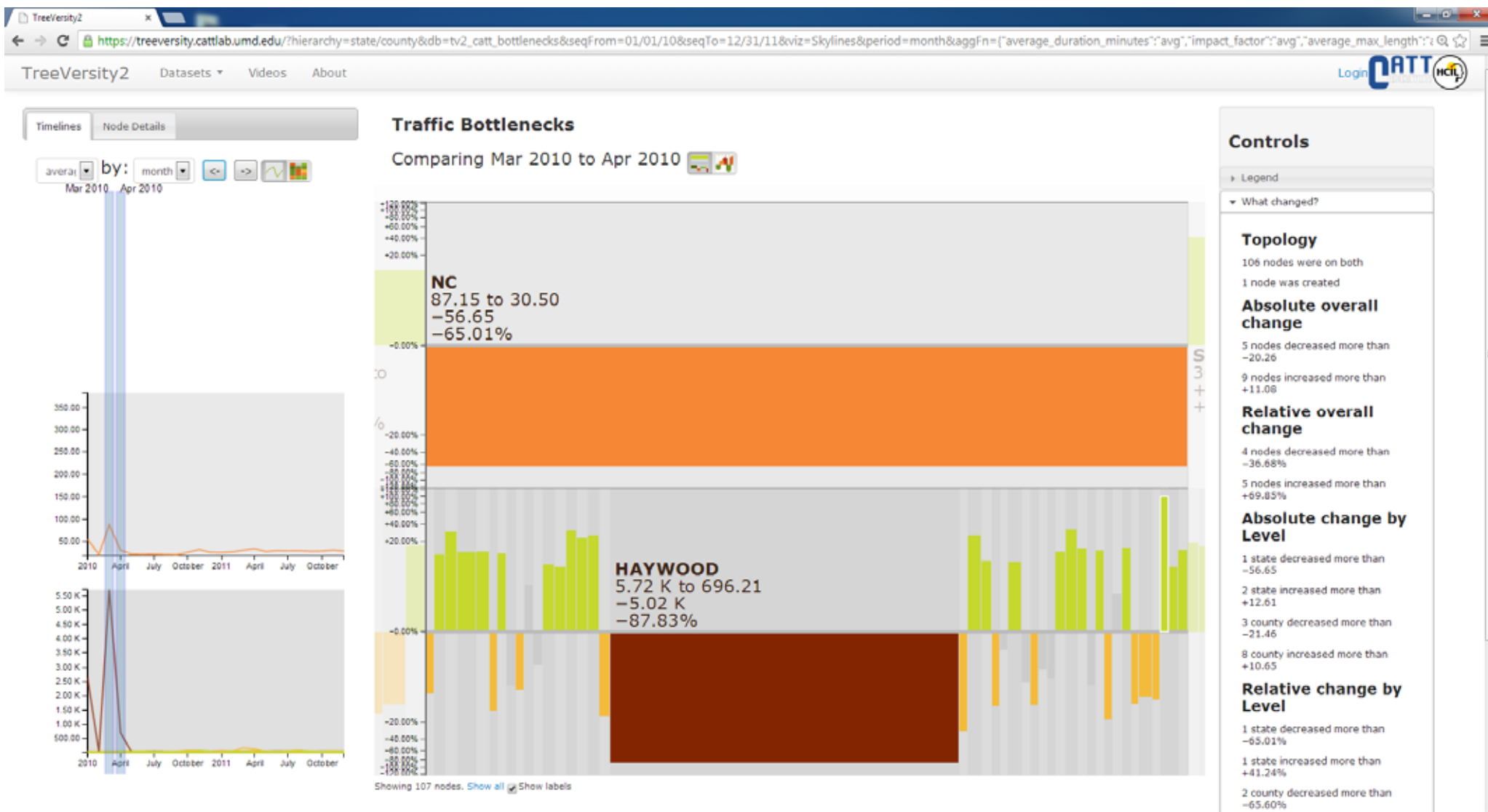
3 county decreased more than −21.46

8 county increased more than +10.65
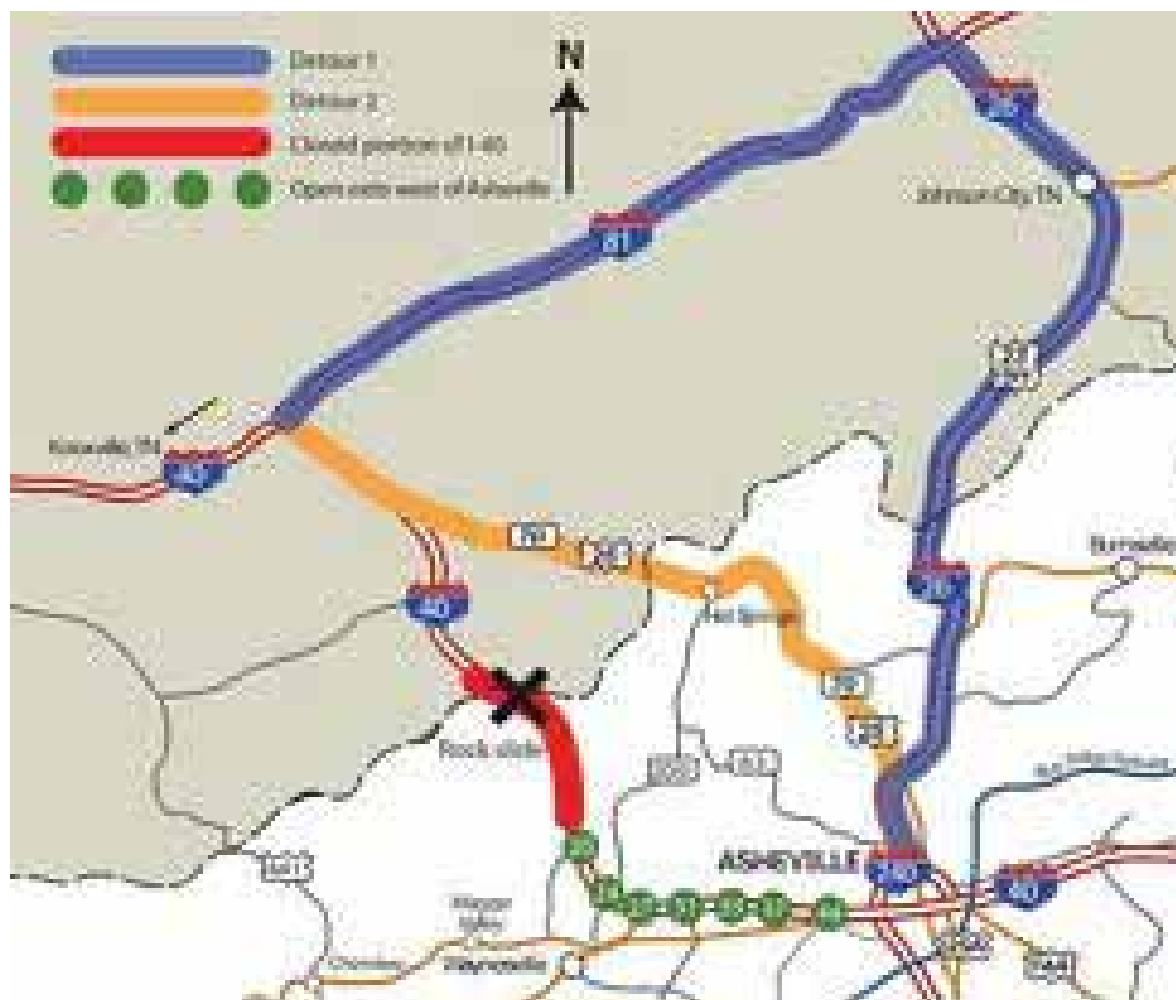
Relative change by Level

1 state decreased more than −65.01%

1 state increased more than +41.24%

2 county decreased more than −65.60%

Legend:
- Detour 1
- Detour 2
- Closed portion of I-40
- Open lane west of Asheville

N

Knoxville TN · Johnson City TN · ASHEVILLE · Rock slide

Resources (give me your card, and I'll email these to you)

- **Info Viz Books:**
  1) [Information Visualization: Perception for Design, 2nd ed.](#) by Colin Ware
  2) [Information Visualization: Design for Interaction 2nd ed.](#) by Robert Spence
  3) [Introduction to Information Visualization](#) by Richardo Mazza
  4) [The Visual Display of Quantitative Information](#) by Edward Tufte
  5) [Now You See It](#) by Stephen Few

- **Info Viz Articles, Theses, Dissertations, & Publications:**
  1) [Visual tools for the socio–semantic web](#) by Moritz Stefaner
  2) [Computational Information Design](#) by Ben Fry
  3) [Information Interaction Design](#) by Nathan Shedroff
  4) [Information Visualization in the News](#) by Alberto Cairo (draft)
  5) [Graphs via Ink: Understanding How the Amount of Non-data Ink in a Graph Affects Perception and Learning](#) (PDF) by Julia Kulla-Mader
  6) [The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations](#) by Ben Schneiderman
  7) [Information Visualization for the People](#) by Mike Danziger

Resources

- **Info Viz Blogs:**
  1) Visual Complexity
  2) Infosthetics
  3) Simple Complexity
  4) Flowing Data
  5) Infographics News
  6) Biofusion Design
  7) Eager Eyes
  8) Neoformix
  9) Statistical Graphics and more
  10) Well-formed data

- **Info Viz Software/Tools:**
  1) ManyEyes
  2) NYTimes Visualization Lab
  3) iCharts
  4) Processing
  5) Flare
  6) Tableau
  7) Swivel
  8) Google Visualization API

  9) GGobi
  10) Protovis

- **Influential Data Viz People:**
  1) Edward Tufte
  2) Ben Shneiderman
  3) Stephen Few
  4) Fernanda Viégas
  5) Martin Wattenberg
  And 60+ more ...

Thank you!

- Michael L. Pack
  PackML@umd.edu
  301.405.0722