Transforming Geospatial Data for Visualization with D3

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Boston Region Metropolitan Planning Organization
Agenda

• Who we are
• Project context
• Implementation vehicle
• Overview of dashboard data
• Presentation of linear data
• Conclusion
• Q&A
Who We Are

- Metropolitan Planning Organizations (MPOs)
- Boston Region MPO
- Central Transportation Planning Staff (CTPS)
Metropolitan Planning Organizations

• Federally mandated and federally funded transportation planning agencies

• Introduced by Federal-Aid Highway Act of 1962

• Required for all U.S. urbanized areas with populations greater than 50,000
Boston Region MPO

• Geographic scope
  • 101 municipalities in the Boston metro area
  • Boundary roughly defined by I-495

• Membership
  • MassDOT, MBTA, MBTA Advisory Board, Massport, MAPC, RTAC, 6 cities, 7 towns
  • FHWA, FTA (non-voting)
Central Transportation Planning Staff

• Staff to the Boston Region MPO

• Expertise in comprehensive, multimodal transportation planning and analysis

• In-house dedicated GIS, data-development and software group
Project Context

- Federal mandate for performance-based planning
- Define performance metrics
- Set goals
- Collect data
- Track and report progress

- CRashes
  Motorized injuries/deaths
  16,869/124

- Congestion
  Congested express highways

- Bridges
  Structurally deficient bridges

- Pavement condition
  Interstates in fair or better condition

- Sidewalks
  Sidewalk to roadway ratio
The Performance Dashboard

- Fulfill federal requirements
- Present data to the public on the web
- Accurate, navigable, interactive presentation
Implementation Vehicle: D3.js

- **D3** = Data-driven documents
- JavaScript library
- Developed by Mike Bostock at Stanford visualization lab
- First released in 2011
- Free / open-source
Transformation, Not Representation

- A web page is a data structure
- Transform it, based on user data
  - Structure
  - Appearance
  - Behavior
- Foundation: *The Grammar of Graphics*
Dashboard Data

• Tabular
  • Census demographics
  • Crash count per town

• Geospatial
  • Point – crash location
    • Data is confidential
  • Line – roads
  • Polygon – town- and census-boundaries
Linear Geospatial Data

- Pavement condition
- Congestion
- Sidewalk coverage
- Bicycle facilities
Data Sources

- Pavement condition, sidewalk coverage
  - Annual MassDOT Road Inventory
- Congestion
  - INRIX speed-run data processed by CTPS
- Bicycle facilities
  - MassDOT Bicycle Accommodation Inventory
  - MAPC Bicycle and Pedestrian Mapping Index
Source Data Formats

• Pavement, sidewalks, congestion
  • ArcSDE feature classes
• Bicycle facilities
  • Shapefile
  • ArcSDE feature class
• Source data exported to GeoJSON format
  • ogr2ogr, esri-to-open
Linear Data

- Linear transformation
- *Non*-linear transformation
Linear Transformation

- Pavement condition
- Congestion
Pavement Condition

- **Metric:** Present Serviceability Index (PSI)
- PSI is a measure of a road’s roughness
  - 5 → Excellent
  - 0 → Poor
Sample Road Inventory Record
(GeoJSON Format)

```json
{
    "coordinates": [[-71.22469420065103, 42.30296805460002], [-71.22474753776642, 42.30307874118052]],
    "type": "Feature",
    "id": 1,
    "properties": {
        "ROUTESYSTEM": "I-95",
        "MILEAGECOUNTED": 1,
        "SURFACETYPE": 6,
        "IRIYEAR": 2013,
        "TOMEASURE": 0.02,
        "FEDERALFUNCTIONALCLASS": 1,
        "ROUTETO": 35.55580000000005,
        "NUMBEROFPEAKHOURLANES": 4,
        "TRUCKNETWORK": 1,
        "RPA": "MAPC",
        "ROUTEDIRECTION": "NB",
        "ASSIGNEDLENGTH": 0.02,
        "FUNCTIONALCLASSIFICATION": 1,
        "ROUTEKEY": "I95 NB",
        "ROUTETYPE": 1,
        "ROADINVENTORY_ID": 26246800,
        "PSIYEAR": 2013,
        "ADTDERIVATION": 1,
        "ADT": 169398,
        "JURISDICTION": "1",
        "COUNTY": "K",
        "IRI": 124,
        "ROUTENUMBER": "95",
        "FACILITYTYPE": 1,
        "MHS": 0,
        "CITY": 199,
        "FROMMEASURE": 0.0,
        "PSI": 2.88707553,
        "ROUTEFROM": 35.5477,
        "ROADSEGMENT_ID": 262468,
        "NUMBEROFTRAVELLANES": 3,
        "STRUCTURALCONDITION": 2,
        "TRUCKROUTE": 1,
        "FEDERALAIDROUTENUMBER": "I-95",
        "ADTYEAR": 2013,
        "MPO": "Boston Region",
        "SPEEDLIMIT": 55,
        "NHSSTATUS": 1,
        "STREETNAME": "YANKEE DIVISION HIGHWAY"
    }
}
```
One Road Segment
One Road Segment in Local Context
In the Context of an Entire Route
In the Context of the Regional Express Highway System
Temporal PSI Overview – All Interstates
Temporal PSI Overview – I-90
D3’s curveBasis smooths discrete data points
Congestion

Metric: Speed Index (SI)

\[ SI = \frac{\text{observed speed}}{\text{posted speed limit}} \]
Sample Congestion Data Record (GeoJSON Format)

{"type":"LineString",
"id":8,
"properties":{
    "SPD_LIMIT":30,
    "TO_MEAS":11478.2641,
    "FROM_MEAS":10704.5063000000001,
    "ROAD_NAME":"NULL",
    "DIRECTION":"Westbound",
    "AM_SPD_IX":1.2600923,
    "SEG_END":"Toll Plaza/Exit 18",
    "PM_SPD_IX":0.98233948,
    "RID":6,
    "ROUTE_NUM":"I-90",
    "SEG_BEGIN":"Toll Plaza/Exit 20"},
"arcs":[1]}
Speed Index: Express Highways
Speed Index: Arterial Routes
Speed Index: One Arterial Route
Non-linear Transformation

Linear data isn’t always best presented as a line!
Dense Linear Data

Sidewalk coverage
Sparse Linear Data

Off-road bicycle facilities
Solution

- Aggregate data by geographic unit
  - Municipality
  - Census tract
  - Traffic analysis zone (TAZ)
- Display aggregated data
  - Choropleth map
  - Bar chart
  - Enhanced x-y scatter plot
Metrics

- **Sidewalk coverage**
  
  \[
  \text{miles of non-\text{limited access roads with sidewalks}}
  \]
  
  \[
  \text{centerline miles of non-\text{limited - access roads}}
  \]

- **Off-road bicycle facilities**
  
  - Miles per municipality
Sidewalk Coverage

- Enhanced x-y scatter plot
Off-road Bicycle Facilities

- Choropleth map
- Bar chart
Conclusion

• Single visualization framework
  • Spatial data
  • Non-spatial data
• Web server *is* spatial data server
• Open format data
  • CSV, TSV, GeoJSON, TopoJSON
• Rich presentation
Check Out the Dashboard

www.ctps.org/dv/lrtp_dashboard
Thank You

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