Method for Calculating Roadway Congestion

Presenter:

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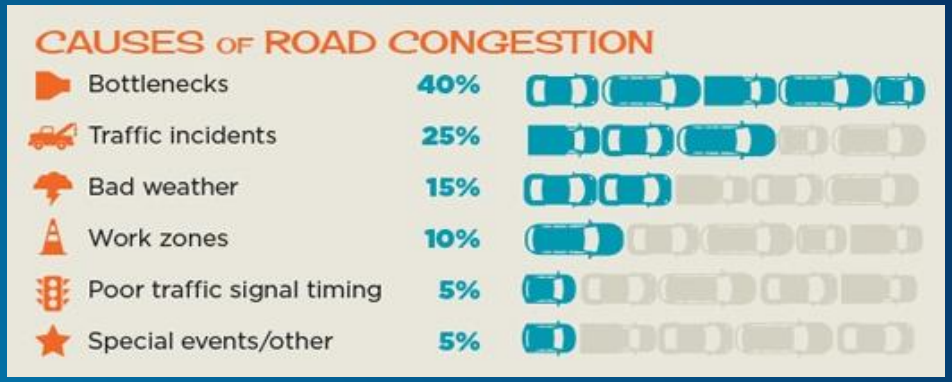
Introduction

- **Purpose:**
  - **To quantify and communicate congestion on highways and local streets.**
  - **To provide a clear method to help manage, score, and evaluate planned projects in Transportation Planning.**
- **Summary:**
  - **This process builds on work conducted in the UTP Ranking and Scoring tool.**
    - **UTP is TxDOT's Unified Transportation Program, a 10-year plan to guide transportation project development.**
    - **However, differs by not using INRIX speed data set (derived from observed of GPS devices daily) or daily volume to capacity ratios.**
  - **This method evaluates roadway segments in one mile increments**
    - **In each 1 mile segment, it compares the density of vehicles measured in feet and the resulting space between vehicles.**

Theory of Method

When thinking about congestion there are a lot of factors to consider:

- **Traffic accidents/incidents**
- **bad weather**
- **work zones**
- **poor traffic signal timing**
- **occasional special events**



Source: Nationwide Insurance Graphic from FHWA data

- **drivers skill, experience, and familiarity with the roadway**

However, these factors are hard to account for, so this method is focused on those factors that are easier to account for in 1 mile segments:

- **Number of lanes (changes like bottlenecks)**
- **Size and Number of vehicles (cars, trucks)**
- **Average Annual Daily Traffic**
- **Average Annual Daily Traffic**
- **Cars per minute**
- **Car Space**

Setup the Process

The process will run using the following software:

- ESRI ArcMap, Python, Excel, Notepad

Data Sources:

- **TxDOT Roadways (un-routed EOY data on TxDOT.gov)**
  - Download most recent EOY data:

  www.txdot.gov/inside-txdot/division/transportation-planning/roadway-inventory.html

  Use Layer file TxDOT_Roadway_Linework

  Use TxDOT Roadways Inventory Table (RHINO) - from download of EOY data
- **This process is designed for centerline data**
  - Filter un-routed linework, TxDOT_Roadways_Linework, by Centerline, *ROUTE_ID LIKE '%-KG'*.
  - Export selected records as a feature class to TxDOT_Roadway_Inventory.gdb
  - Name file TxDOT_Roadway_Linework_Centerline.
  - ***Note*: *Very important to name file generated exactly as stated in process. Python script will not be able to find file without precise naming convention.***
- RHINO file needs to be filtered by On-System Main lanes (*No right and left roadbeds*)
  - Filter Open Traffic Highway Status, *REC = 1 AND HWY_STAT > 3*.
  - Export selected records to TxDOT_Roadway_Inventory.gdb as TxDOT_Roadway_Inventory_Centerline
  - Process can be applied to all roadway segments (on & off system) or a selection of routes/systems by applying a definition query when dissolving route events.
    - Same definition query should be applied when creating the one mile roadway segments.

Process Steps 1 2 3

- **Step 1**
- **Run the following script against TxDOT_Roadways**
  - **Name the script RoadwaySegments.py**
  - **Python Script on Wiki page Calculate Roadway Congestion**
  - **Copy script into Python shell and run it.**
  - **Script produces a .csv file called Open OneMileSegments.csv**
- **Step 2**
- **Open the OneMileSegments.csv file in ArcMap & export as a table to the TxDOT_Roadway_Inventory_Geodatabase folder and name it OneMileSegments**
- **Step 3**
- **Use Overlay Route Events tool in the Linear Referencing toolbox in ArcGIS**
  - **Union TxDOT_Roadway_Inventory_Centerline and OneMileSegments**
  - **Use the Union Type of Overlay**
  - **Export table to TxDOT_Roadway_Inventory.gdb**
  - **Delete any resulting 0 length records (uncheck "Keep zero length line events")**
  - **Keep all attributes (leave checked "Include all fields from input")**
  - **Resulting table needs records removed that have "zeroed out" attributes.**
  - **Select by Attributes, query ADT_CUR = 0, delete resulting records selected.**

Process Steps 4 & 5

Step 4

Summarize the result of the union in step 3 based on the SEGMENT_ID field with the following options:

- First RIA_RTE_ID - (Route Identification Number)
- Minimum FRM_DFO - (Beginning point _Distance From Origin)
- Maximum TO_DFO - (End point _Distance From Origin)
- Average ADT_CUR - (Average Daily Traffic)
- Average TRK_AADT - (Annual Average Daily Truck Traffic)
- Average K_FAC - (Annual average daily traffic occurring in an hour)
- Average NUM_LANES - (Number of Lanes)

Name the resulting file Roadway_Inventory_SegmentID_Summarized

Step 5

- **Add the following fields to table created in step 4:**
  - AVG_CAR_LENGTH (SHORT)
  - CARS_PER_MIN (FLOAT)
  - CAR_SPACE (FLOAT)
  - LEN_SEC (FLOAT)
  - TRUCKS (LONG)

Process Steps 6 & 7

- **Step 6**
- **Field calculations are as follows:**
- **AVG_CAR_LENGTH = 15**
- **LEN_SEC = Maximum_TO_DFO – Minimum_FRM_DFO**
- **TRUCKS = Average_ADT_CUR * (Average_TRK_AADT * .01)**
- **CARS_PER_MIN =**
  - **((([Average_ADT_CUR] + [TRUCKS]) * ([Average_K_FAC] *.01)) / [Average_NUM_LANES]) / 60**
- **CAR_SPACE =**
  - **((5280) - ((((([Average_ADT_CUR] + [TRUCKS]) * ([Average_K_FAC] *.01)) / [Average_NUM_LANES]) / 60) * [AVG_CAR_LENGTH])) / [CARS_PER_MIN]**

Step 7

- **Route Roadway_Inventory_SegmentID_Summarized to TxDOT_Roadways_Centerline**
  - **using First_RIA_RTE_ID as the route identifier.**
  - **Export the results to a feature class in the TxDOT_Roadway_Inventory.gdb**

Process Step 8: Categorizing Results

Symbolize the data using the CAR_SPACE column as follows:

Heavy Congestion: Car_Space < 175 (Red, 4 line width)

Moderate Congestion: Car_Space >= 175 and Car_Space < 350 (Orange, 2 line width)

Little Congestion: Car_Space >= 350 (Light gray, 0.1 line width)

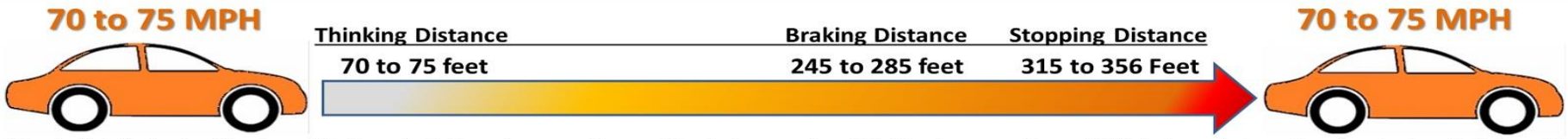
Highway Congestion

Heavy Congestion

Average Car Length is 15 feet. Thinking Distance is approximately 1 foot per 1 MPH. Braking Distances are based on brakes being in good condition and clear weather conditions. Braking Distances will at least double in wet conditions.

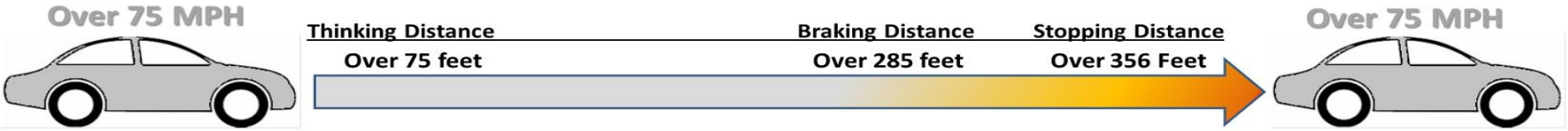
Highway Speed Limits are a minimum of 50 to 55 mph.
If cars have to travel less than 50 mph on a major highway then traffic is not flowing and is considered heavy congestion because there is not enough space between cars for the needed stopping distance, 175 feet.

Moderate Congestion



When traffic is flowing in a 70 mph speed limit zone, typically most cars are going over 70 mph. As cars go from 74 to 75 mph, cars require over 350 feet of space between them in order stop. Traffic is considered moderate congestion because there is less than 350 feet of space between cars for stopping.

Little Congestion

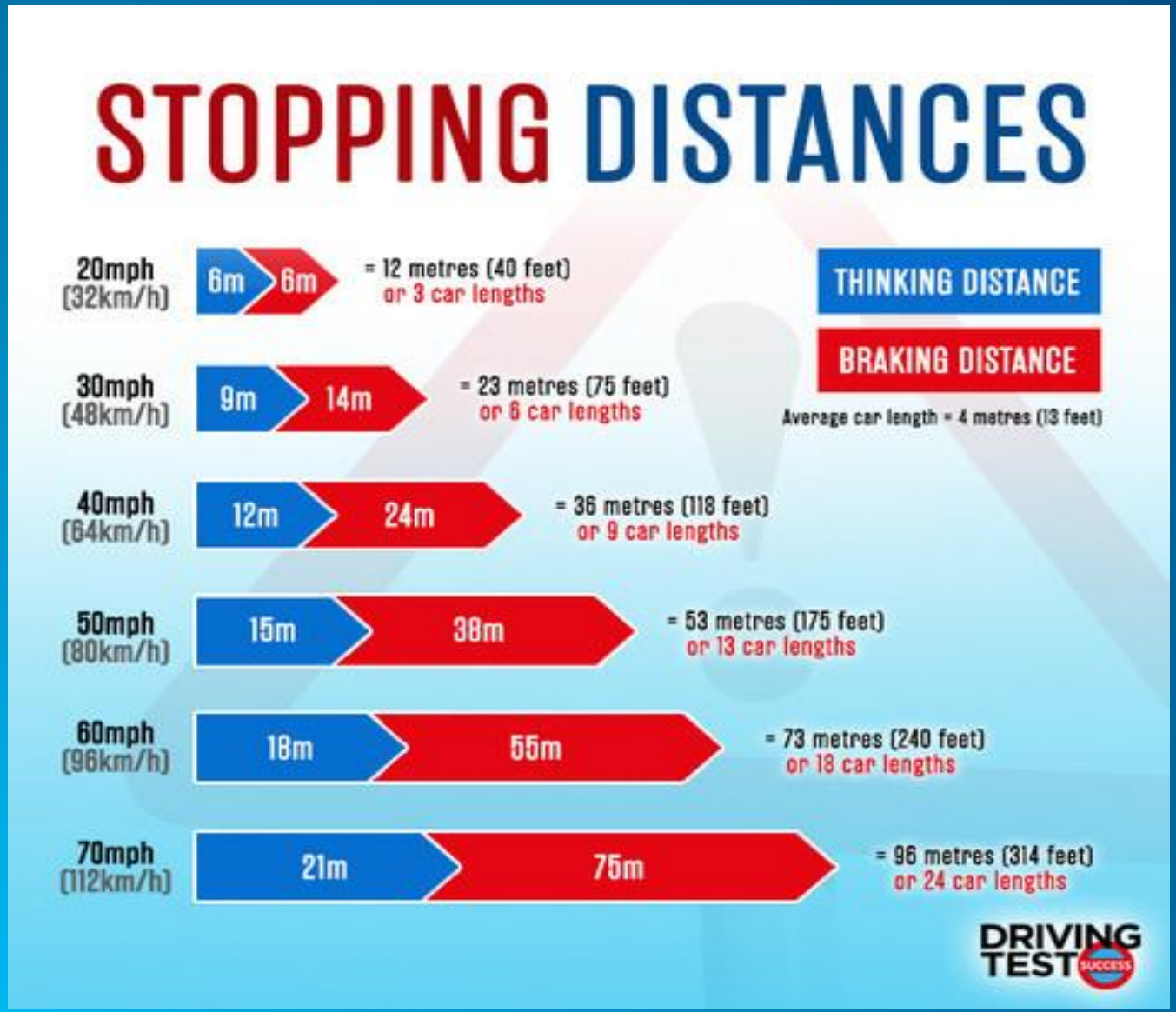


If there is over 350 feet of space between vehicles, then traffic is considered to be little to no congestion as the space between cars increases.

**Stopping distances are based on Driving Test Success.com and TxDOT congestion calculations.*

Driving Test Success.com Diagram

As you can see the results correspond to standard sources for stopping distances.



Final Step 9

Step 9

Add categorized layer (feature class) to a simple map with TX DOT Roadways linework centerline, cities, counties and districts.

Review the results in urban and rural areas for obvious errors or questionable results.

ArcGIS Online Web Service: Calculate Roadway Congestion App

Conclusions

This method simplifies the process of calculating roadway congestion by focusing on certain primary factors in 1 mile segments:

- Length of Cars
- Number of Lanes
- Annual Average Daily Traffic
- Annual Average Daily Truck Traffic
- Annual Average Daily Traffic occurring in an hour

Method excludes more complicated factors that are hard to predict and calculate.