ArcGIS Decision Support Tool for Infrastructure Improvement

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Kansas Dept. of Transportation
ArcGIS Decision Support Tool for Infrastructure Improvement

Presentation Outline

• Background
• Analysis of Data
• Goals
• Methodology & Approach
• The Decision Support Tool
• Conclusion & Outlook
Background: Freight Corridors of Significance

Credit: KDOT/Kansas Freight Advisory Committee (2014)
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Credit: KDOT
KTRIPS* Oversize Overweight (OSOW) Truck Routes Terminology

- OSOW Load
  - Truck Height > 14’ or Weight > 40T or Length >120’ or Width > 8 ‘ 6 ”

- Super Loads are >75 T

- OSOW Loads Not Allowed on Posted Bridges

- OSOW Loads > 60T Not Allowed on Restricted Bridges

- KTRIPS*: Kansas Intelligent Truck Routing System
Analysis/Classification of OSOW Data

<table>
<thead>
<tr>
<th>Travel_Type_2014</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>INBOUND</td>
<td>923</td>
<td>1248</td>
<td>1564</td>
<td>1611</td>
<td>1600</td>
<td>1764</td>
<td>1454</td>
<td>1590</td>
<td>1560</td>
<td>1479</td>
<td>1127</td>
<td>1443</td>
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<tr>
<td>INTERSTATE</td>
<td>1963</td>
<td>2500</td>
<td>2822</td>
<td>2758</td>
<td>2493</td>
<td>2867</td>
<td>2931</td>
<td>2872</td>
<td>2832</td>
<td>3362</td>
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<td>2748</td>
</tr>
<tr>
<td>INTRASTATE</td>
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<td>583</td>
<td>701</td>
<td>635</td>
<td>815</td>
<td>724</td>
<td>746</td>
<td>698</td>
<td>698</td>
<td>711</td>
<td>552</td>
<td>496</td>
</tr>
<tr>
<td>OUTBOUND</td>
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<td>1448</td>
<td>1488</td>
<td>1529</td>
<td>1375</td>
<td>1722</td>
<td>1577</td>
<td>1631</td>
<td>1657</td>
<td>1755</td>
<td>1308</td>
<td>1250</td>
</tr>
<tr>
<td></td>
<td>4152</td>
<td>5579</td>
<td>6575</td>
<td>6533</td>
<td>6283</td>
<td>7077</td>
<td>6708</td>
<td>6791</td>
<td>6747</td>
<td>7307</td>
<td>5870</td>
<td>5947</td>
</tr>
</tbody>
</table>

2014 OSOW Vehicle Count Categories

- **INBOUND**
- **INTERSTATE**
- **INTRASTATE**
- **OUTBOUND**
### Analysis/Classification of OSOW Data

Oversize Overweight (OSOW) Routes Geometry Available from KTRIPS Summary Classification of Data for 2 Years

<table>
<thead>
<tr>
<th>Tonnage</th>
<th>Truck height OR Load Height</th>
<th>Total of Year 2014 &amp; 2015 counts</th>
<th>Percent Count</th>
<th>*Barrier Bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 60 T</td>
<td>&lt;=14 FT</td>
<td>83,371</td>
<td>56.3</td>
<td>P</td>
</tr>
<tr>
<td>&lt; 60 T</td>
<td>&gt; 14 FT AND &lt;=18 FT</td>
<td>23,564</td>
<td>15.9</td>
<td>P/V</td>
</tr>
<tr>
<td>&lt; 60 T</td>
<td>&gt; 18 FT</td>
<td>402</td>
<td>0.3</td>
<td>P/V</td>
</tr>
<tr>
<td>60 T-75 T</td>
<td>&lt;=14 FT</td>
<td>13,152</td>
<td>8.9</td>
<td>P/R</td>
</tr>
<tr>
<td>60 T-75 T</td>
<td>&gt; 14 FT AND &lt;=18 FT</td>
<td>11,592</td>
<td>7.8</td>
<td>P/R/V</td>
</tr>
<tr>
<td>60 T-75 T</td>
<td>&gt; 18 FT</td>
<td>36</td>
<td>0.0</td>
<td>P/R/V</td>
</tr>
<tr>
<td>&gt; 75 T</td>
<td>&lt;=14 FT</td>
<td>3,681</td>
<td>2.5</td>
<td>P/R</td>
</tr>
<tr>
<td>&gt; 75 T</td>
<td>&gt; 14 FT AND &lt;=18 FT</td>
<td>11,924</td>
<td>8.1</td>
<td>P/R/V</td>
</tr>
<tr>
<td>&gt; 75 T</td>
<td>&gt; 18 FT</td>
<td>353</td>
<td>0.2</td>
<td>P/R/V</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>148,075</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P: Posted
*P/R: Posted OR Restricted
*P/R/V: Posted OR Restricted OR Limited Vertical Clearance
Analysis of OSOW Derived Data: Origin and Destination (OD) Pairs
Identifying Origin-Destinations and Frequency (Python Scripts)

Classifying Interstate, Inbound, Outbound and Intrastate OSOW Freight
Goals

Project Prioritization
Goals

- Developing an ArcGIS Python Scripts Tool for Prioritizing Bridge Improvement Projects Using OSOW Truck Routing Data

- Analyze OSOW Truck Routes
- Help Visualize OSOW Data
- Support Objective Decision Making
- Utilize Available Data
- Provide Easy to Use & Easily Modifiable Tools
- Prioritize Bridges for Improvement Projects
Methodology & Approach

Network Analyst
Analysis & Problem Solving Using Network Analyst

Required:

• ArcGIS Network Analyst Extension
• Routable Network Dataset (Used ESRI Data & Maps: StreetMap North America Dataset)
• Origin & Destination (OD) Pairs: Point Features
• Barrier Bridges- Point Features Snapped to Network Dataset

Optional:

OSOW Truck Route Geometry
Network Data Set Properties

The network dataset has been built. If the network dataset or any of its sources have been edited you should rebuild the network to update its connectivity and attributes before running any solvers.

Network Dataset Version
This 10.1 network dataset matches the ArcGIS release you are currently using.
## Network Data Set Properties

### Network Dataset Properties

Specify the attributes for the network dataset:

<table>
<thead>
<tr>
<th>Name</th>
<th>Usage</th>
<th>Units</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>DrivingTime</td>
<td>Cost</td>
<td>Minutes</td>
<td>Double</td>
</tr>
<tr>
<td>Length</td>
<td>Cost</td>
<td>Miles</td>
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</tr>
<tr>
<td>Oneway</td>
<td>Restriction</td>
<td>Unknown</td>
<td>Boolean</td>
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</table>

### Attributes

- **Add…**
- **Remove**
- **Remove All**
- **Rename**
- **Duplicate**
- **Ranges…**
- **Parameters…**
- **Evaluators…**
Methodology: Analyzing each OD Pair

- Find Shortest Path Geometry & Travel Time Without Barrier Bridges
- Select Intersecting Bridges on Shortest Path
- Apply Barriers Specific to Each OD pair, Get Travel Time
- Compute the Additional Travel Time due to Barriers
- Assign the Additional Travel Time to the Barriers as ‘TimeLost’
- Increment a ‘Counter’ to Count the Routes Which Intersect the Barrier Bridges
- Aggregate the ‘Time Lost’ and ‘Counter’ Fields for all OD Pairs
- Prioritize Based on Maximum ‘TimeLost’ Values
- Remove the Bridges from the top of priority barrier list
- Re-calculate Travel Time Cost for all OD Pairs
Computation Time Issues: Approach

• Reduce Number of OD Pairs to be Analyzed
  - Rounding Lat, Long to Consolidate Locations

• Reduce Size of Network Data Set
  - Extracted State Highway segments
  - Applied ‘Dissolve’ on the extracted subset

• Use OSOW Route Geometry

• Make OD Cost Matrix Option: output_path_shape: NO_LINES
• Make Route Layer Option: output_path_shape: NO_LINES (Finding Route with Barriers)
## OSOW Truck Classification: Total Counts and OD Pair Frequency

<table>
<thead>
<tr>
<th>Tonnage</th>
<th>Truck height OR Load Height</th>
<th>Total of Year 2014 &amp; 2015 counts</th>
<th>Percent Count</th>
<th>Frequency of approx OD pair locations (2 Decimal approx for LAT, LONG)</th>
<th>OD pair locations with &gt;10 count frequency</th>
<th>*Barrier Bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 60 T</td>
<td>&lt;=14 FT</td>
<td>83,371</td>
<td>56.3</td>
<td>18,165</td>
<td>10,941</td>
<td>P</td>
</tr>
<tr>
<td>&lt; 60 T</td>
<td>&gt; 14 FT AND &lt;=18 FT</td>
<td>23,564</td>
<td>15.9</td>
<td>5637</td>
<td>309</td>
<td>P/V</td>
</tr>
<tr>
<td>&lt; 60 T</td>
<td>&gt; 18 FT</td>
<td>402</td>
<td>0.3</td>
<td>231</td>
<td></td>
<td>P/V</td>
</tr>
<tr>
<td>60 T-75 T</td>
<td>&lt;=14 FT</td>
<td>13,152</td>
<td>8.9</td>
<td>6977</td>
<td>135</td>
<td>P/R</td>
</tr>
<tr>
<td>60 T-75 T</td>
<td>&gt; 14 FT AND &lt;=18 FT</td>
<td>11,592</td>
<td>7.8</td>
<td>4690</td>
<td>112</td>
<td>P/R/V</td>
</tr>
<tr>
<td>60 T-75 T</td>
<td>&gt; 18 FT</td>
<td>36</td>
<td>0.0</td>
<td>14</td>
<td></td>
<td>P/R/V</td>
</tr>
<tr>
<td>&gt; 75 T</td>
<td>&lt;=14 FT</td>
<td>3,681</td>
<td>2.5</td>
<td>1155</td>
<td>55</td>
<td>P/R</td>
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<td>&gt; 75 T</td>
<td>&gt; 14 FT AND &lt;=18 FT</td>
<td>11,924</td>
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<td>P/R/V</td>
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<tr>
<td>&gt; 75 T</td>
<td>&gt; 18 FT</td>
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<td>78</td>
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<td>P/R/V</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>148,075</strong></td>
<td><strong>38,714</strong></td>
<td><strong>11,723</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*P* Posted

*P/R* Posted OR Restricted

*P/R/V* Posted OR Restricted OR Limited Vertical Clearance
The Decision Support Tool

Python Scripts
Python Script Tool

File Geodatabase

Origins

Destinations

Barriers

Process Step

OK  Cancel  Environments...  Show Help >>
### Bridge Improvement Projects Prioritization

<table>
<thead>
<tr>
<th>BRID_LATITUDE</th>
<th>Shape</th>
<th>CLEARANCE</th>
<th>Counter</th>
<th>TimeLost</th>
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<tbody>
<tr>
<td>37.3629</td>
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<td>36</td>
<td>685</td>
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<tr>
<td>38.96726</td>
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<td>37.91243</td>
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<tr>
<td>37.95554</td>
<td>Point</td>
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<td>534</td>
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<tr>
<td>38.16165</td>
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<td>534</td>
<td>14'4&quot;</td>
</tr>
<tr>
<td>37.56439</td>
<td>Point</td>
<td>14.67</td>
<td>25</td>
<td>531</td>
<td>14'7&quot;</td>
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<tr>
<td>37.49169</td>
<td>Point</td>
<td>14.83</td>
<td>23</td>
<td>498</td>
<td>14'9&quot;</td>
</tr>
<tr>
<td>38.67108</td>
<td>Point</td>
<td>14.42</td>
<td>9</td>
<td>490</td>
<td>14'4&quot;</td>
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<tr>
<td>38.70911</td>
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<td>14.42</td>
<td>9</td>
<td>490</td>
<td>14'4&quot;</td>
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<tr>
<td>38.7964</td>
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<td>490</td>
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<tr>
<td>37.30453</td>
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<td>490</td>
<td>14'2&quot;</td>
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<td>37.9617</td>
<td>Point</td>
<td>14.5</td>
<td>8</td>
<td>468</td>
<td>14'6&quot;</td>
</tr>
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</table>
Bridge Improvement Projects Prioritization
OD Cost Matrix Analysis After Removing Priority Barriers
Conclusions & Outlook

- The Tool Provides Insight for Planning
- Creates Prioritized List of Bridges for Projects
- Provides Spatial Data Analysis /Visualization

**The Tool Scripts will be Provided for Download on GitHub**

Further Work

- Categorize OD Pairs To Identify Patterns
- Run the Tool for Different Datasets for Further Evaluation
- Explore Ways to Reduce Computation Time
- Investigate Effect of Grouping of Bridges
Acknowledgements

• Penn State MGIS program: Dr. Jan Wallgrun, Capstone Project Advisor

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  John Maddox, Freight/Rail Manager
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Questions?