

# Customizing ArcGIS to Visualize Origin/Destination Model Outputs

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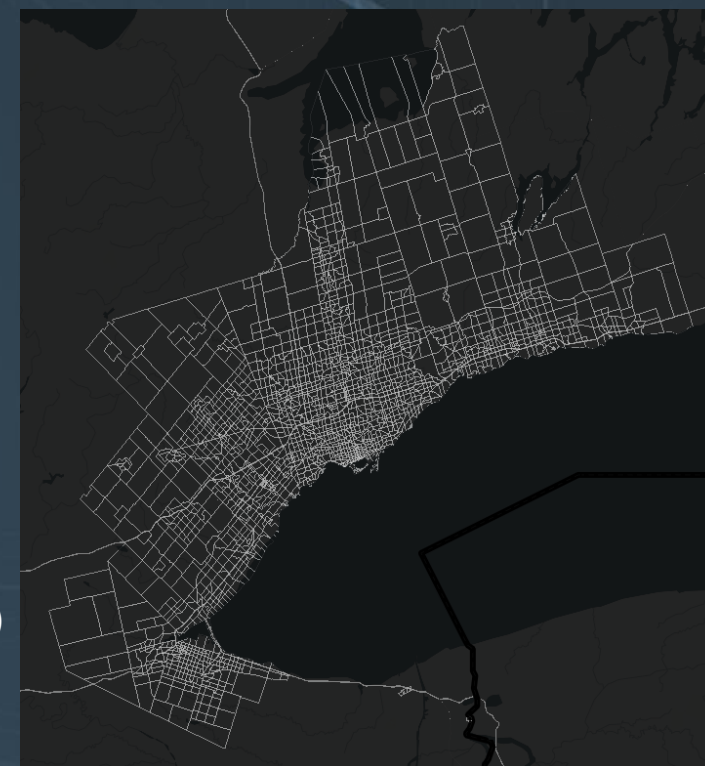
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# Agenda

- Context
  - Simulation of travel metrics in GTAH by UTTRI's Travel Modelling Group
  - Challenges for visualization in GIS
- ArcGIS Pro Add-in
- Custom Web app using the ArcGIS API for JavaScript
- Opportunities for further development

# Context

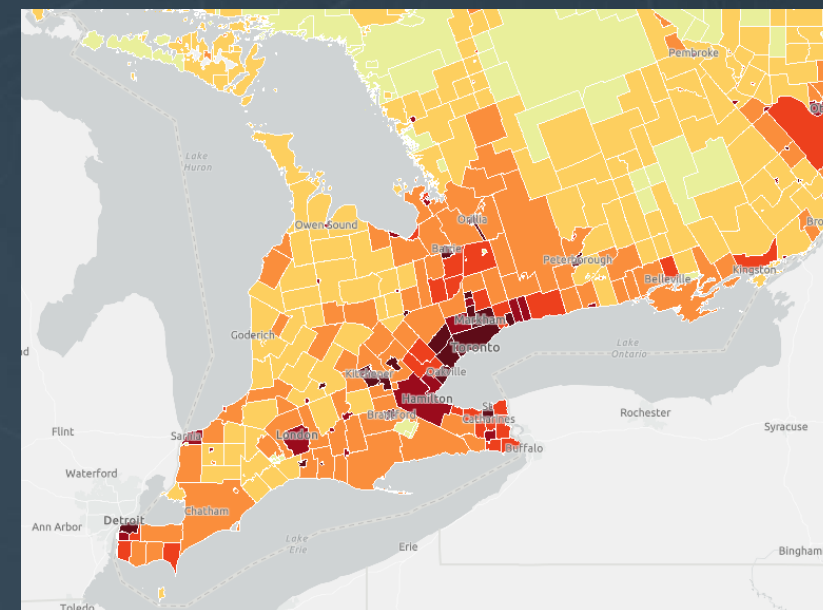
- UTTRI's Travel Modelling Group:
  - **Integrated land use, transportation, environment (ILUTE)**
  - Activity-based travel demand models using Transportation Tomorrow Survey (TTS) to simulate travel metrics:
    - Transit:
      - Travel Time (true, perceived, in-vehicle)
      - Fare (\$)
    - Auto:
      - Travel Time (in-vehicle)
      - Cost (\$)
    - Different times of day:
      - AM (6am-9am), Midday (9am-3pm), PM (3pm-7pm), Evening (7pm-12am)
  - Modelling outputs correspond with 2375 zones in GTAH geographic zones, but are not easily visualized in conventional GIS software...



# Context

- Conventional Geographic Information Systems:
  - Table Rows = geographic features (one geometry per row)
  - Table Columns = attributes (one column per attribute/variable)

	ID	Name	Pop	....	....	....
						
						
						
						
						
						
						
						
						





# Context

- Travel simulation model output:
  - One origin/destination matrix for each metric...

First column of each row = origin zone ID →

	1	2	3	4	5	....
1						
2						
3						
4						
5						
6						
7						
8						
9						
...						

← First row of each column = destination zone ID

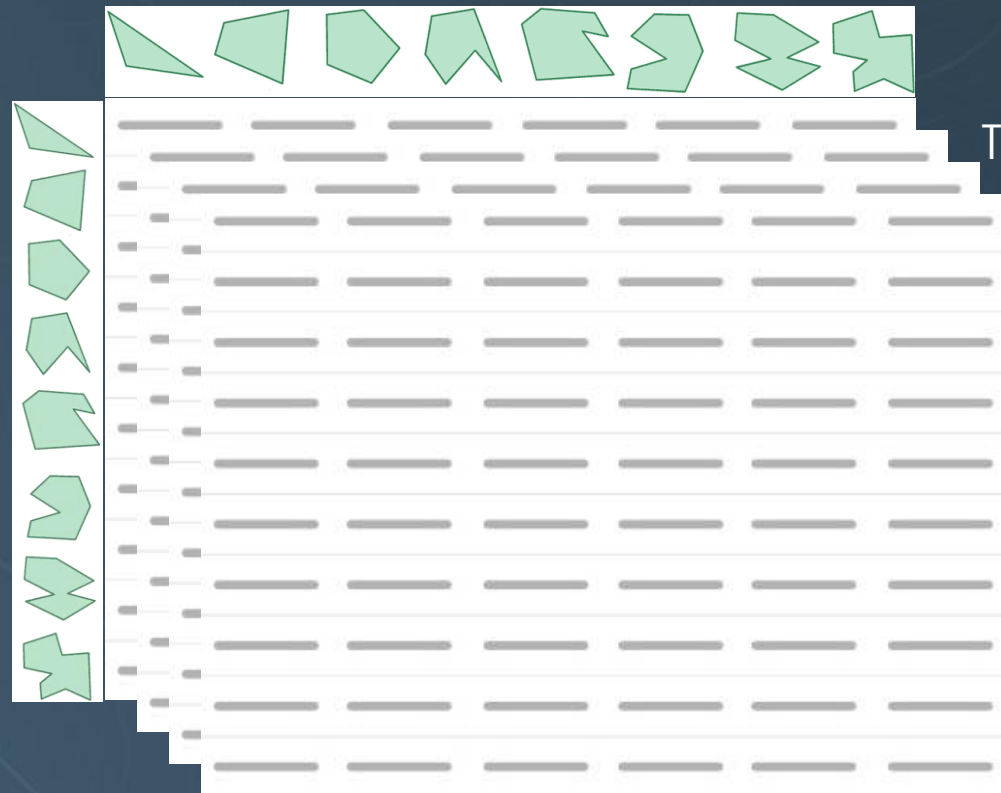
# Context

- Example - O/D matrix for automobile travel cost (\$) in the morning:

Zones O\D	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0.172365	0.227514	0.356373	0.458939	0.489411	0.599534	0.476233	0.846921	0.692802	0.802214	0.782105	0.773223	0.78471	0.795896	0.7324	0.702095
2	0.172365	0	0.158668	0.186777	0.35469	0.253413	0.363536	0.240235	0.610923	0.456804	0.566216	0.546107	0.599562	0.638252	0.633056	0.687401	0.690988
3	0.225731	0.158668	0	0.109293	0.232661	0.257157	0.36728	0.243979	0.614667	0.460548	0.56996	0.549851	0.540969	0.565506	0.560311	0.509445	0.486231
4	0.353964	0.186777	0.109293	0	0.124596	0.122027	0.253804	0.250687	0.50119	0.347071	0.456484	0.436375	0.406035	0.429634	0.424438	0.422153	0.375542
5	0.485998	0.341163	0.232661	0.123899	0	0.106009	0.237786	0.286948	0.410294	0.256175	0.325173	0.305064	0.310484	0.340267	0.335072	0.382796	0.327688
6	0.483429	0.253413	0.26111	0.122027	0.106009	0	0.176306	0.185671	0.360457	0.206338	0.31575	0.295642	0.349096	0.387786	0.38259	0.436935	0.515355
7	0.589474	0.363536	0.367155	0.253804	0.237786	0.176306	0	0.295795	0.494019	0.3399	0.449313	0.429204	0.482658	0.521348	0.516153	0.570498	0.648917
8	0.466298	0.240235	0.243979	0.250687	0.286948	0.185671	0.295795	0	0.543181	0.389062	0.498475	0.478366	0.53182	0.57051	0.565315	0.61966	0.698079
9	0.843288	0.610923	0.620969	0.507618	0.418251	0.360457	0.494019	0.543181	0	0.154234	0.210766	0.190657	0.244112	0.287285	0.28209	0.336435	0.414854
10	0.681212	0.456804	0.458893	0.345542	0.256175	0.206338	0.3399	0.389062	0.154234	0	0.095687	0.075579	0.129033	0.172207	0.167011	0.221356	0.299776
11	0.750209	0.605374	0.527891	0.414539	0.325173	0.31575	0.449313	0.498474	0.210766	0.095687	0	0.097579	0.151033	0.194207	0.189011	0.243356	0.321775
12	0.730101	0.585266	0.507782	0.394431	0.305064	0.295642	0.429204	0.478366	0.190657	0.075579	0.097579	0	0.130925	0.174098	0.168902	0.223247	0.301667
13	0.749822	0.604987	0.527503	0.414152	0.324785	0.371931	0.50161	0.550772	0.271803	0.156725	0.178724	0.158616	0	0.152592	0.147397	0.15325	0.224868
14	0.765304	0.620469	0.542985	0.410279	0.340267	0.387413	0.517092	0.566254	0.287285	0.172207	0.194207	0.174098	0.152592	0	0.076989	0.074746	0.153166
15	0.760108	0.615273	0.53779	0.405083	0.335072	0.382217	0.511896	0.561058	0.28209	0.167011	0.189011	0.168902	0.147397	0.076989	0	0.087729	0.184604
16	0.703042	0.578876	0.480049	0.371287	0.29244	0.40765	0.554511	0.603673	0.336435	0.221356	0.243356	0.223247	0.15325	0.074746	0.087729	0	0.07621
17	0.705462	0.581296	0.482468	0.373707	0.29486	0.410069	0.541847	0.591009	0.414854	0.299776	0.321775	0.301667	0.224868	0.153166	0.184604	0.07621	0

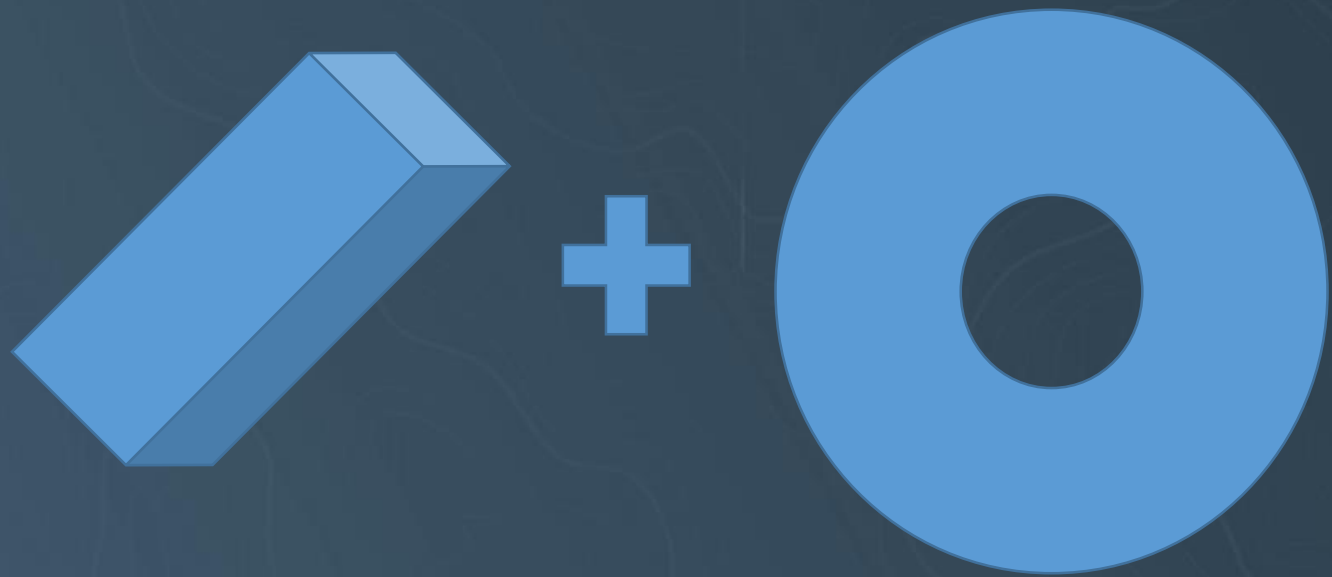
# Origin/Destination Matrix

- Features/Geometry represented in two dimensions (rows and columns)
- Separate matrix for each metric



Transit Travel Time  
Transit Fare  
Auto Travel Time  
Auto Cost





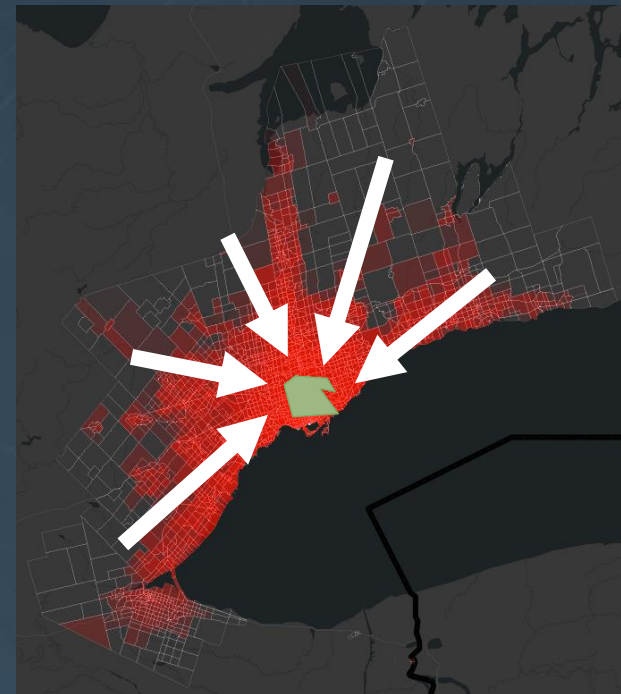




<https://www.geograph.org.uk/photo/1244305>

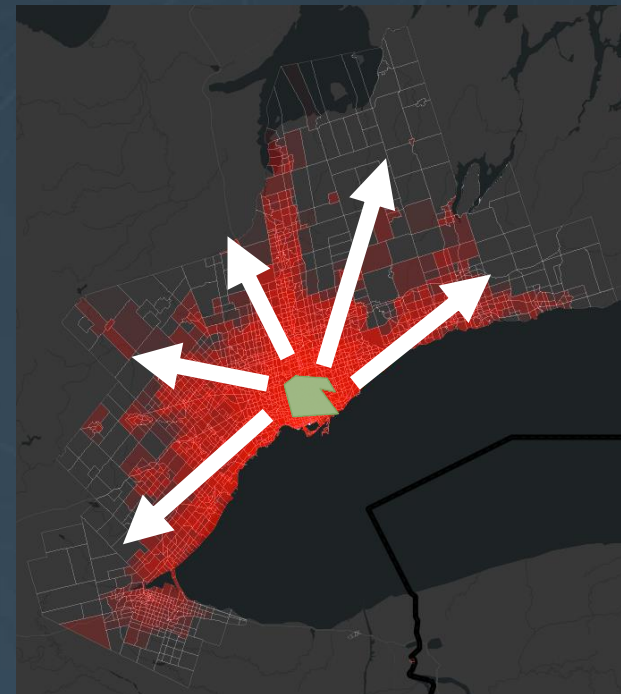
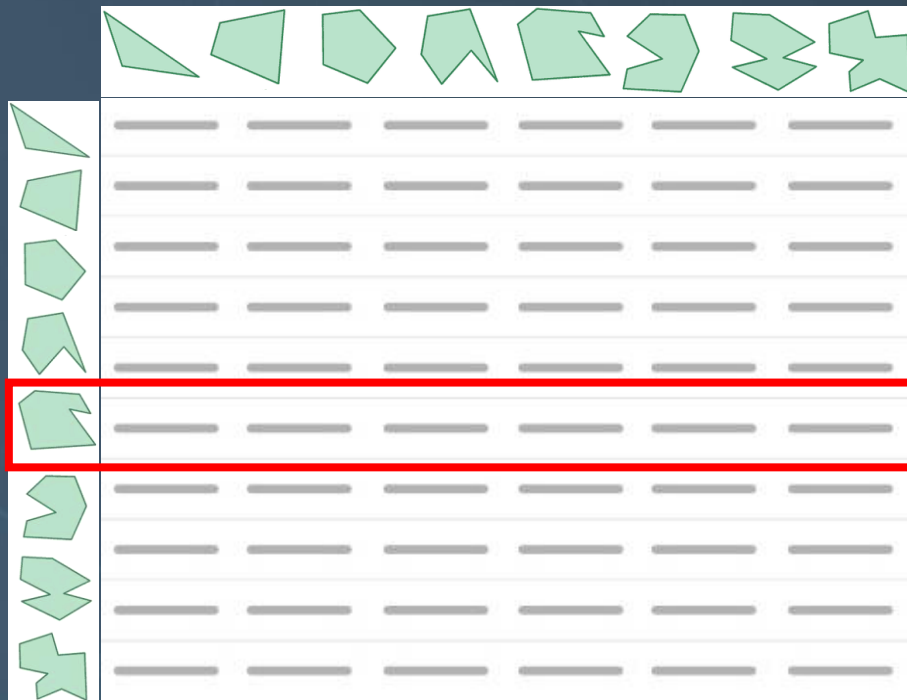
# Origin/Destination Matrix

- Conventional GIS Perspective - use columns as attributes:
  - Show a specific metric for travel to a specific destination from *all* possible origins



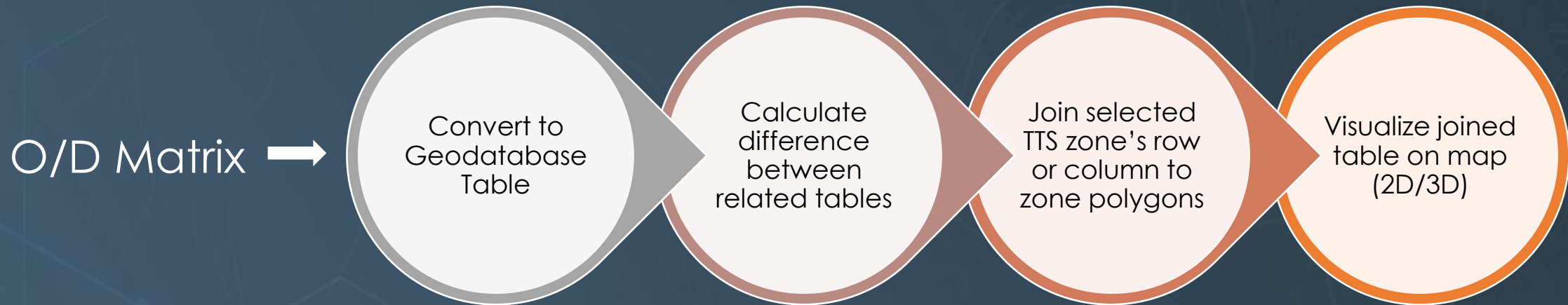
# Origin/Destination Matrix

- Transpose perspective - use *rows* as attributes:
  - Show a specific metric for travel to *all* possible destinations from a specific origin



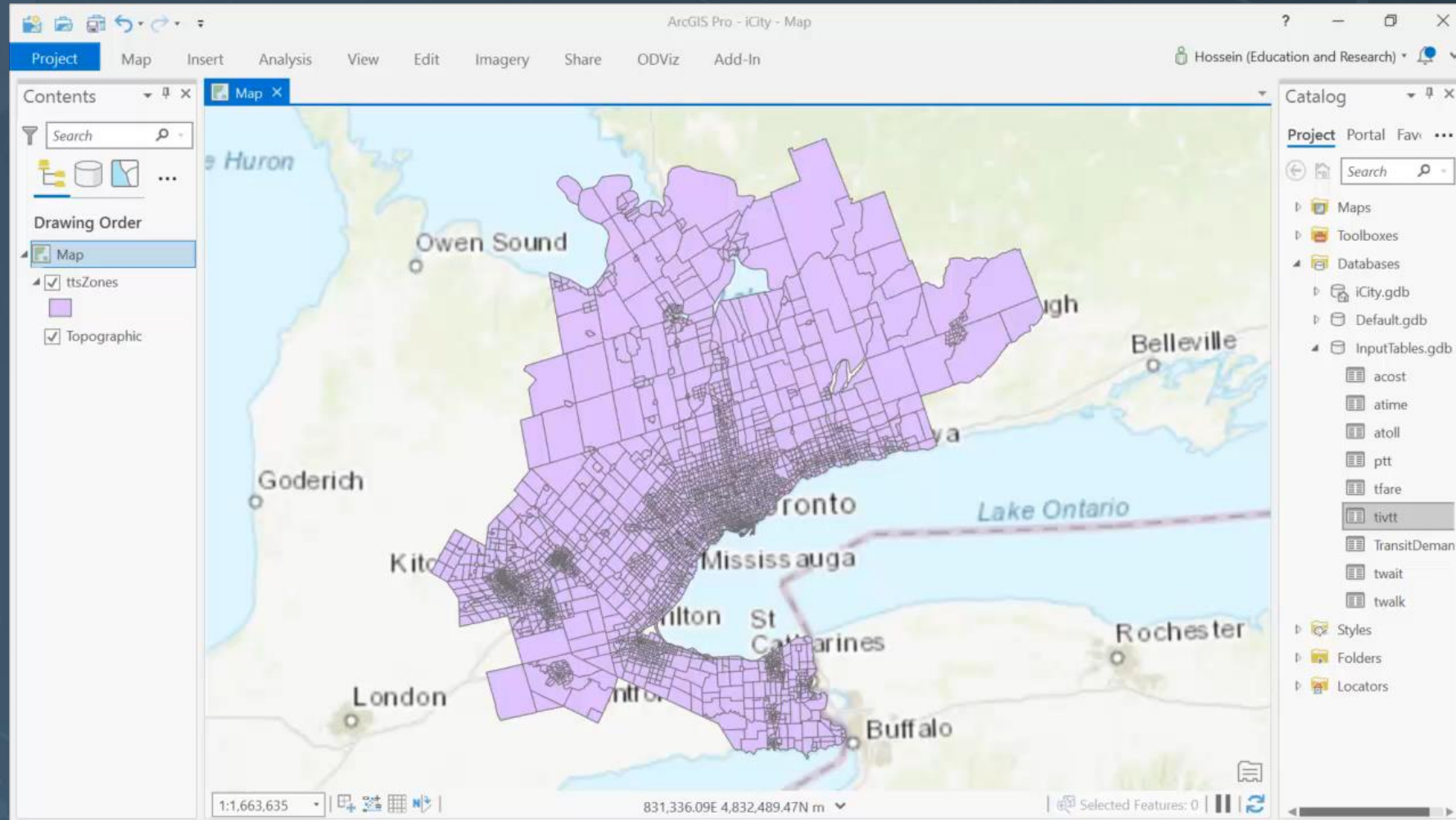
# Custom ArcGIS Pro Add-in

- iCity Research Day 2019: presented prototype developed by Michael Luubert & Hossein Hosseini





# Custom ArcGIS Pro Add-in





# Custom ArcGIS Pro Add-in

- Benefits:
  - Simplifies integration of O/D matrix data into ArcGIS
  - Data can be integrated with any standard analysis/visualization
- Challenges:
  - Only able to view about 0.04% (1/2375<sup>th</sup>) of data at a time for a given O/D matrix
  - Performance constraints:
    - One matrix equivalent to 2375 attribute columns (4750 with both directions considered)
    - Switching display renderer to show travel to/from different TTS zones: 1-2 seconds

# What's next?

- Need fast & interactive visualization:
  - Fast: more complete visualization/exploration of O/D matrices
  - Interactive: more intuitive user experience for visually interpreting and understanding variability of spatial patterns within O/D matrices

# Alternative: Custom Web App using the ArcGIS API for JavaScript

- Douglas Crockford on Java vs. JavaScript:

## Star Trek (Java)



- Phasers
- Photon Torpedoes
- Uniforms
- Regulations

## Star Wars (JavaScript)



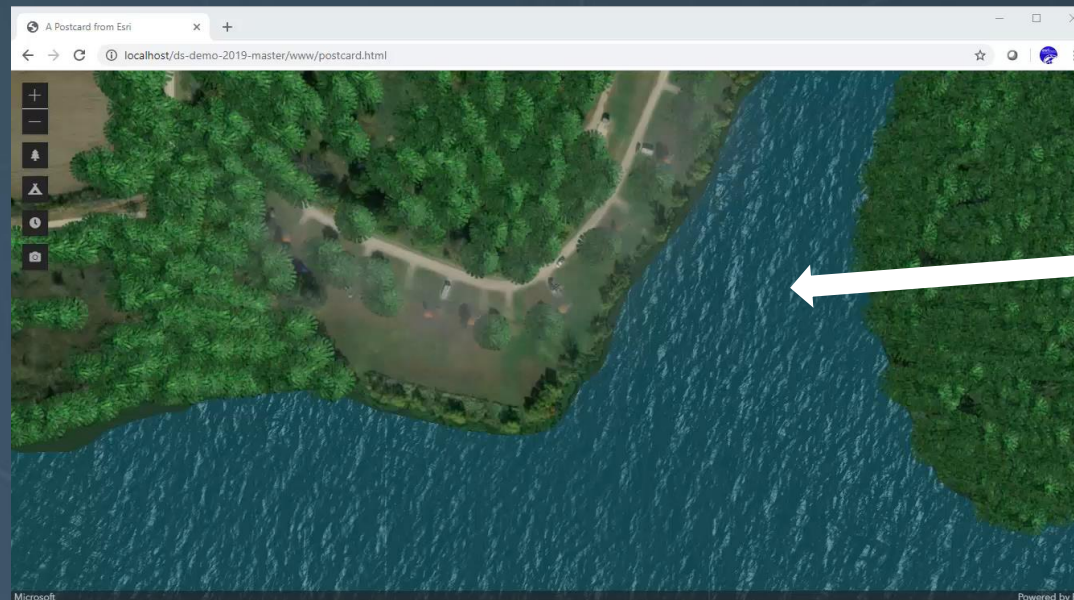
- Lightsabers & Blasters
- Proton Torpedoes
- Sand
- Chaos



(me)

# ArcGIS API for JavaScript

- ArcGIS API for JavaScript – well structured framework for Web GIS apps
- Uses WebGL for rendering – provides interface for custom WebGL code
- Custom WebGL demo presented by Esri at 2019 Developer Summit:



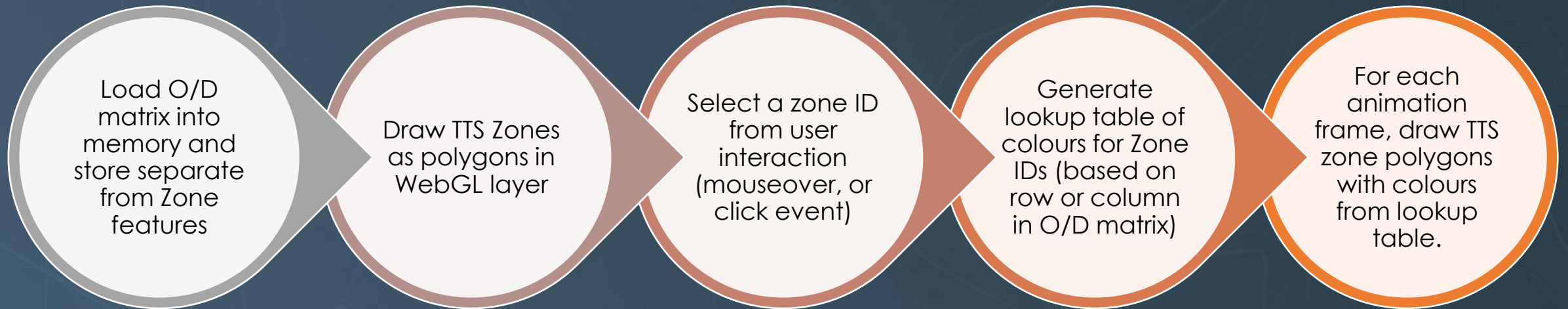
Animated waves  
achieved by  
drawing polygon in  
WebGL with texture...

<https://github.com/damix911/ds-demo-2019>



# ArcGIS API for JavaScript API + Custom WebGL Rendering

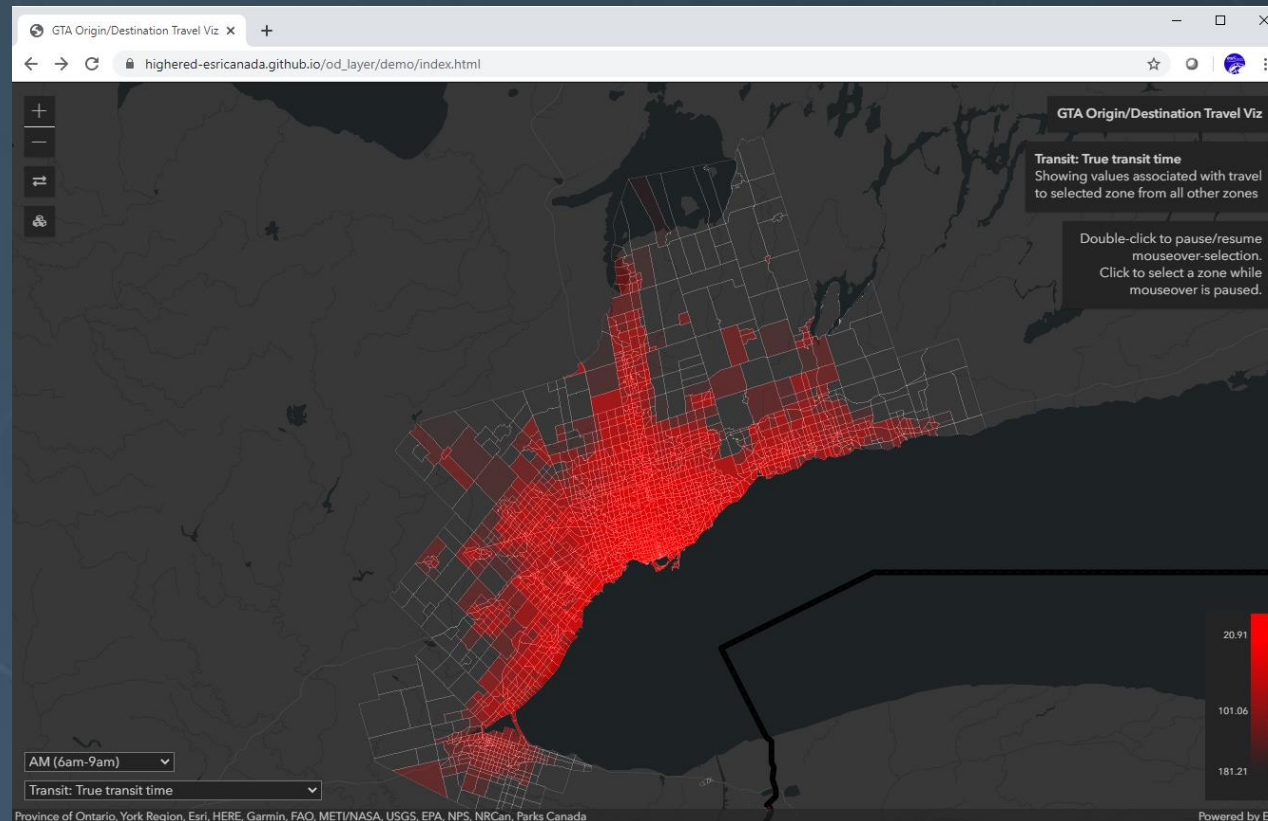
- Custom approach using WebGL rendering with data from O/D matrix:





# ArcGIS API for JavaScript API + Custom WebGL Rendering

- Result = web map interface with fast rendering of O/D matrix data:



[https://github.com/highered-esricanada/od\\_layer/](https://github.com/highered-esricanada/od_layer/)

# Future development opportunities

- Integration with travel modelling systems
- Integration between ArcGIS Pro add-in and custom web app
- Ongoing improvements/updates to the ArcGIS API for JavaScript
- More features (display metrics in charts/displays alongside map view)

# QUESTIONS?

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