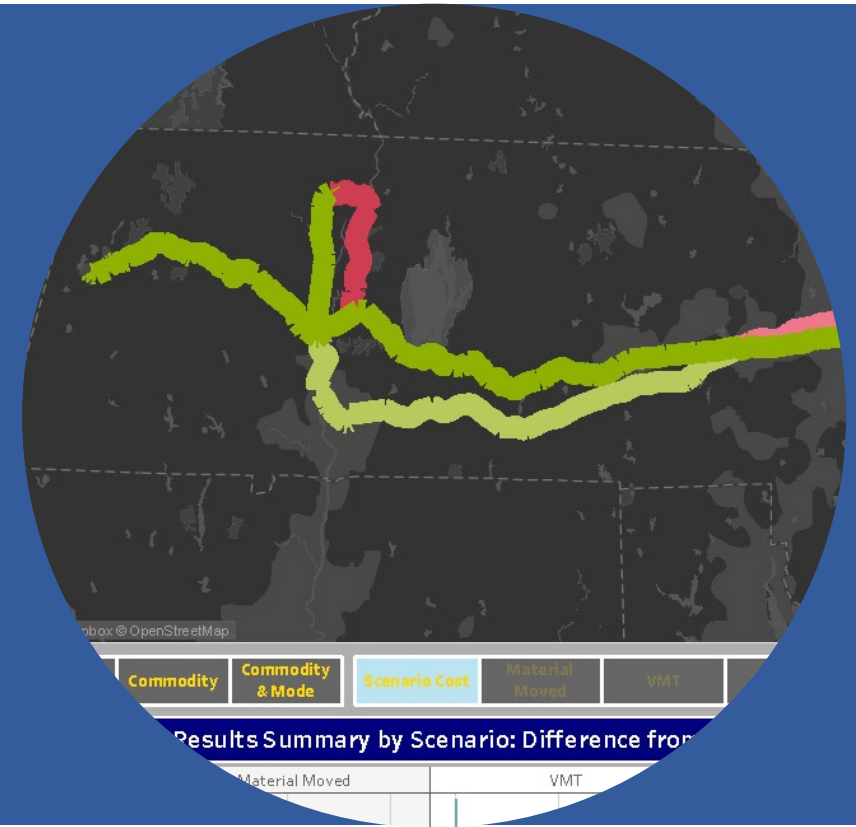


FTOT Link Removal Resiliency Testing Use Case

Question: How resilient is my solution
to disruptions?



[https://github.com/dflynn-volpe/FTOT-Public-Link Removal](https://github.com/dflynn-volpe/FTOT-Public-Link-Removal)

Dan Flynn daniel.flynn@dot.gov

50
YEARS
1970 - 2020



U.S. Department of Transportation

Volpe Center

TRANSPORTATION INNOVATION FOR THE PUBLIC GOOD

Overview

Process

- Complete baseline run in FTOT
- Rank edges by 'importance'
- Disruptions applied by removing edges from optimal solution
- Re-calculate new optimal solution and calculate total scenario cost

in

- ~~the~~ ~~by~~
- ~~single~~ ~~cost~~
- ~~total~~ ~~is~~
- ~~total~~ ~~cost~~ ~~is~~

61

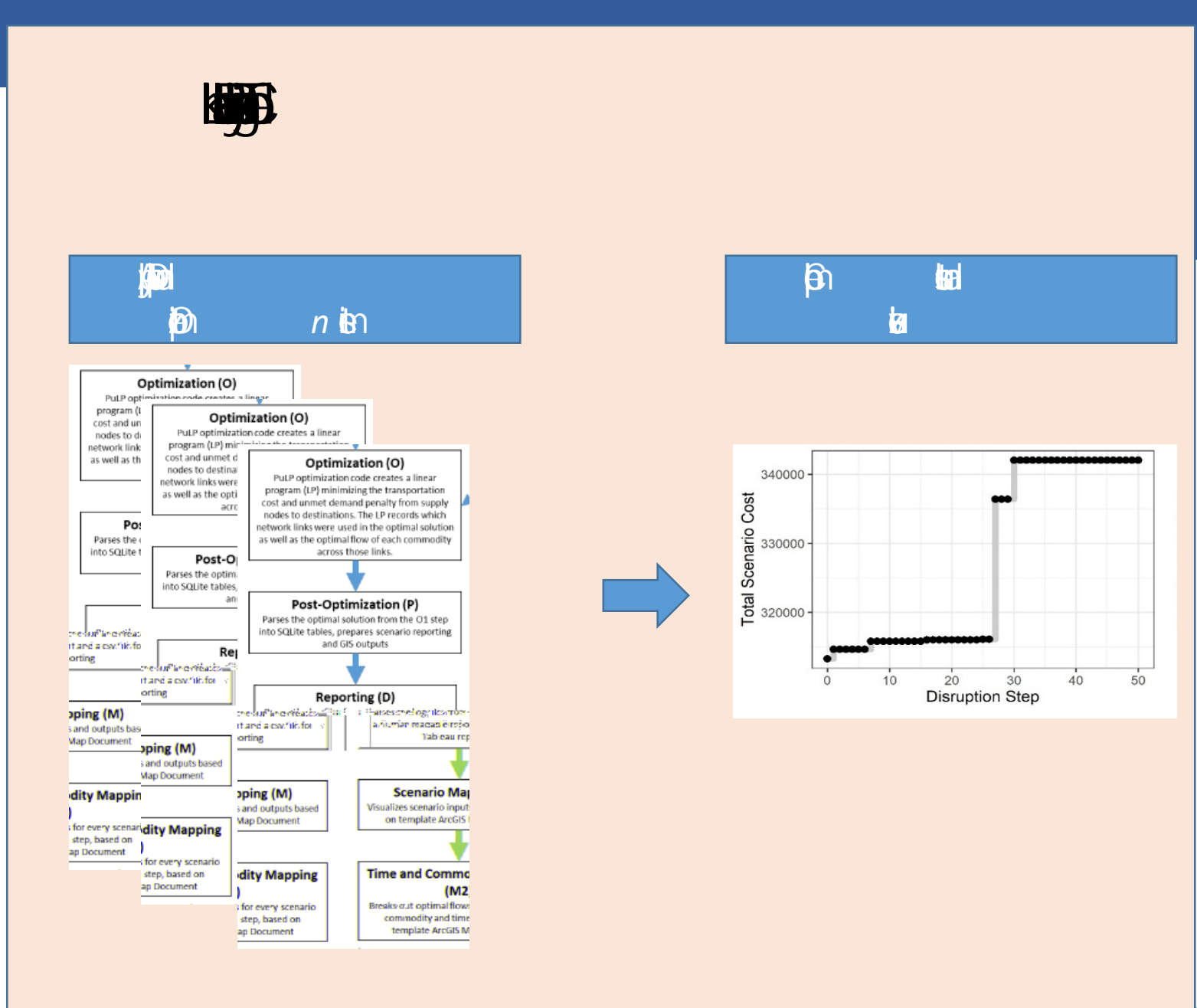
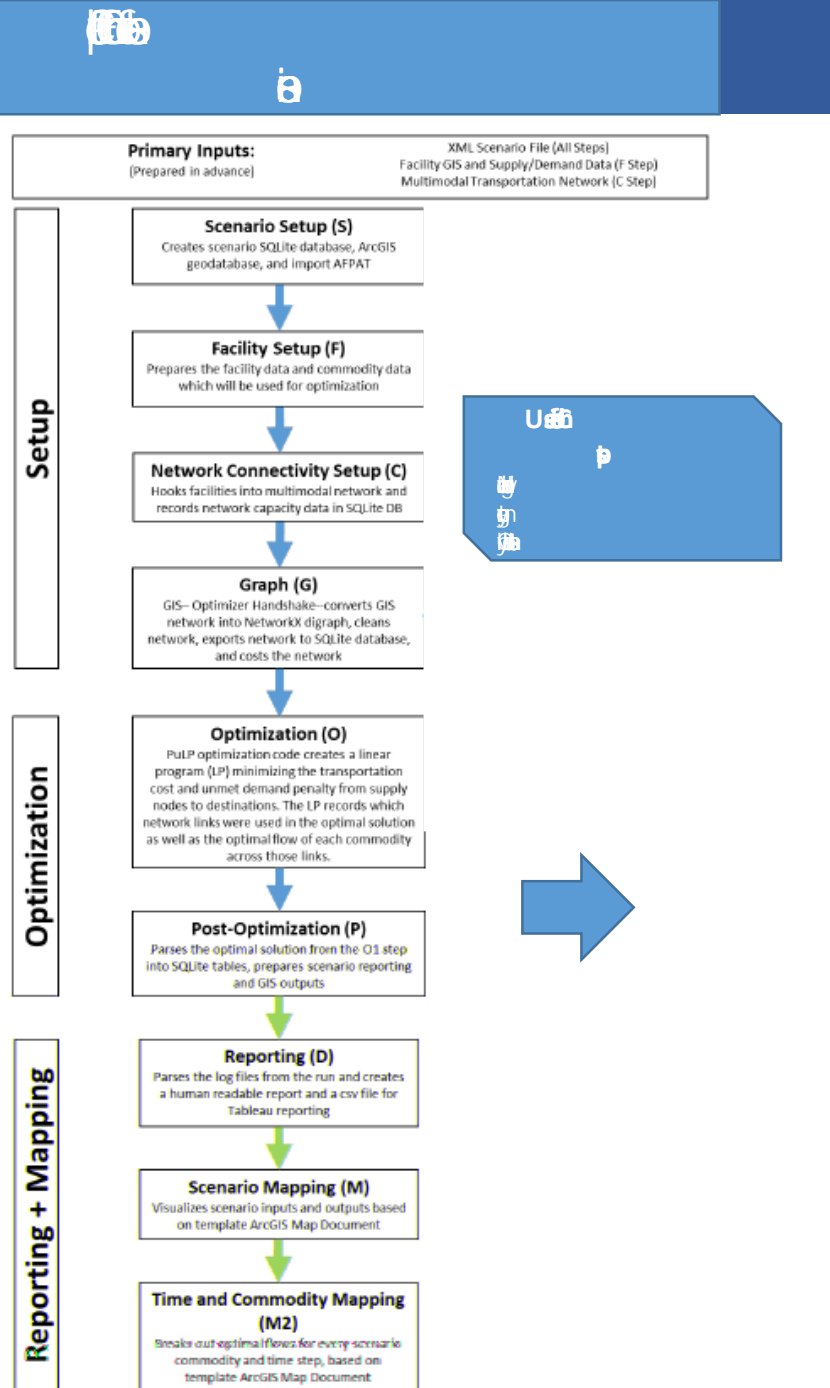
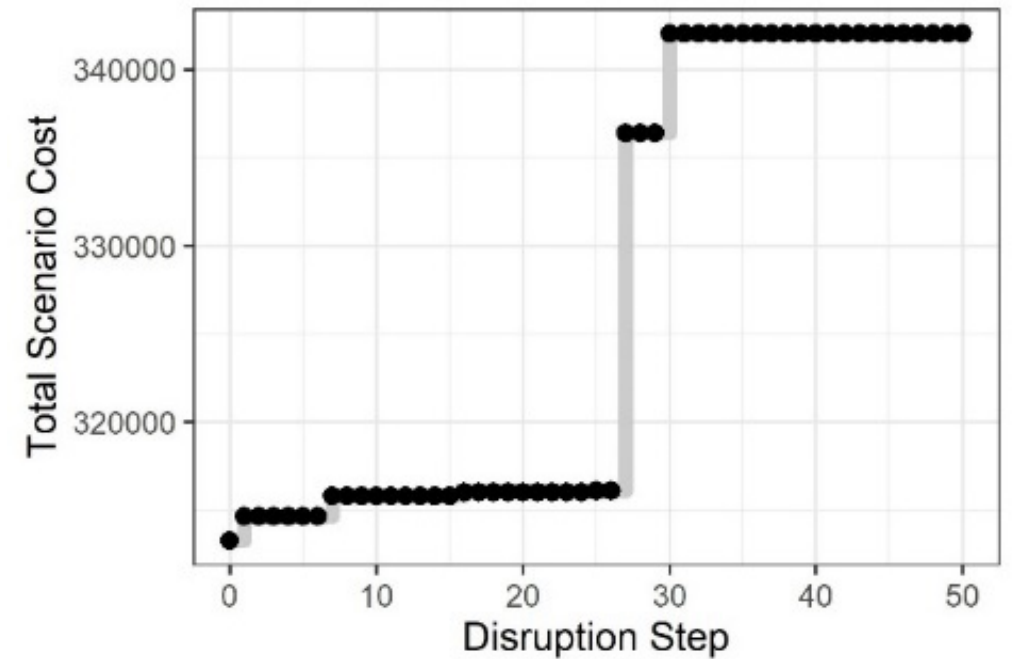
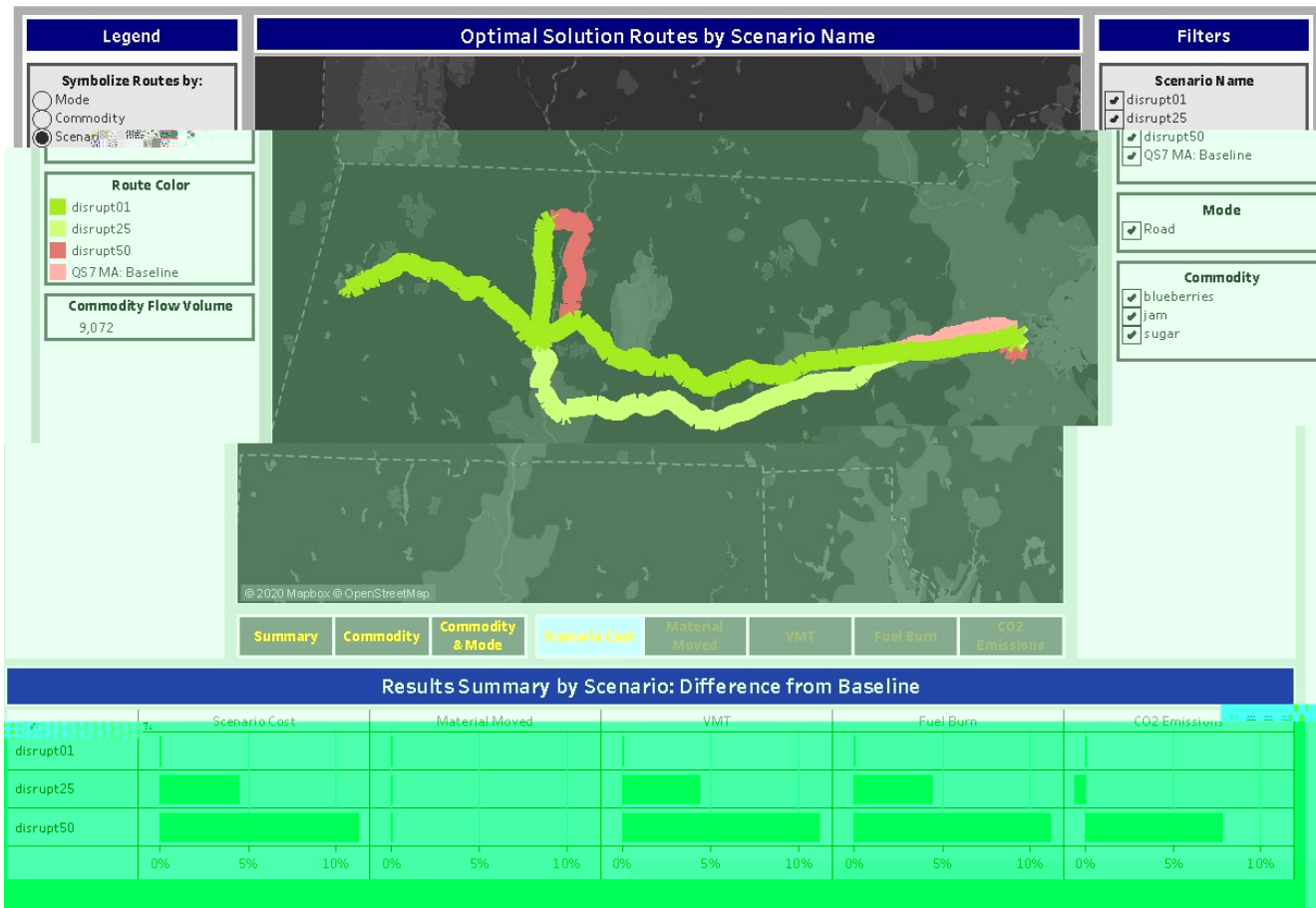


Figure 3 - Analytical tool data flow schematic showing the key components/roles of each component of the FTOT

Example outputs



Development scenarios

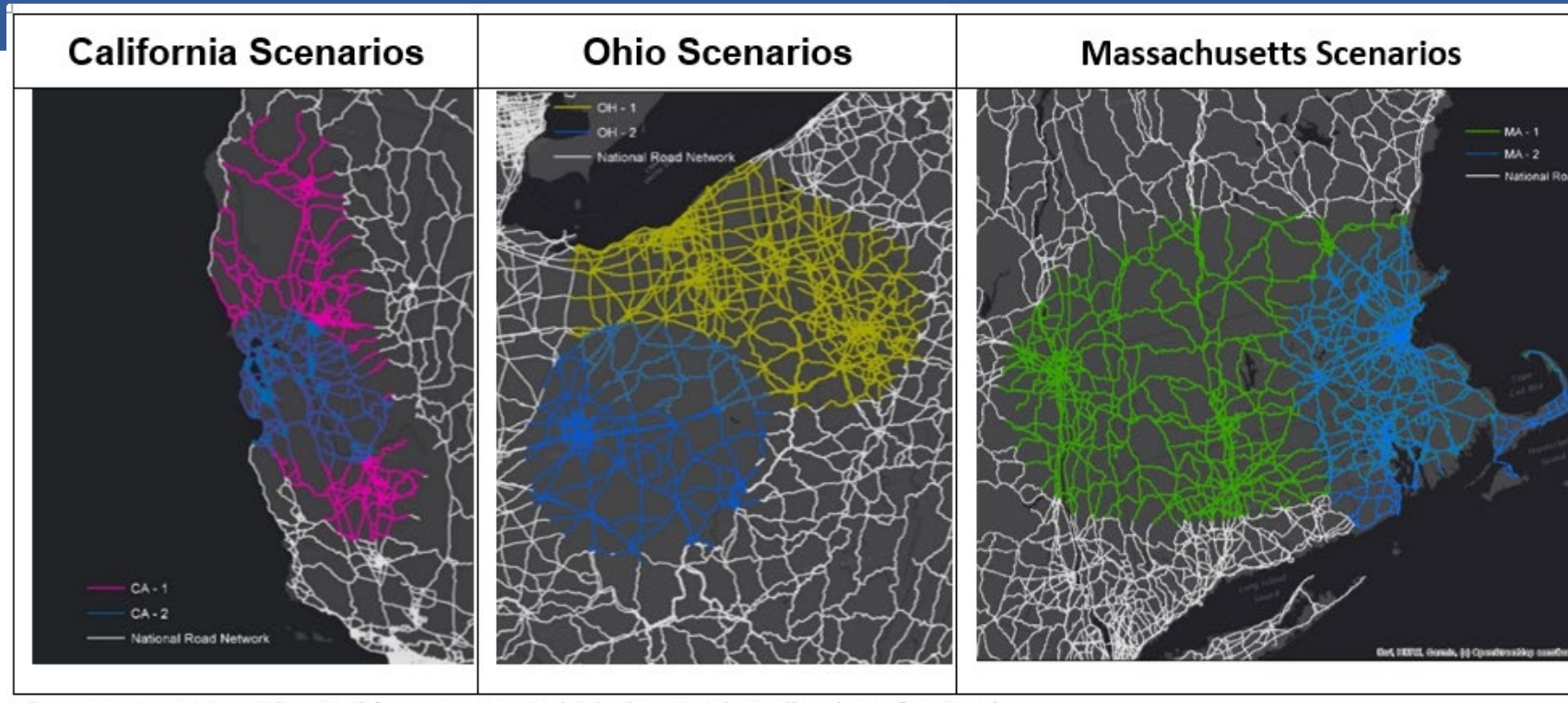
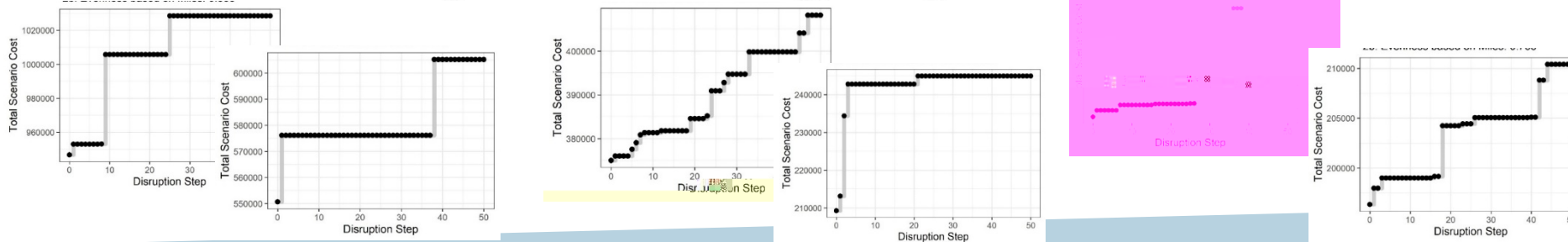


Figure 1: Test networks used for evenness calculations and application of scenarios.



Demo

- To FTOT-Public Wiki

The screenshot shows a web browser displaying the GitHub repository page for VolpeUSDOT / FTOT-Public. The browser's address bar shows the URL `github.com/VolpeUSDOT/FTOT-Public/wiki/FTOT-Projects-and-Use-Cases`. The GitHub navigation bar at the top includes a search bar, a tab for "FTOT Projects and Use Cases", and links for Pull requests, Issues, Marketplace, and Explore. Below the navigation bar, the repository name "VolpeUSDOT / FTOT-Public" is displayed, along with a "Watch" button. A secondary navigation bar contains links for Code, Issues (5), Pull requests, Actions, Projects, Wiki (selected), Security, and Insights. The main content area is titled "FTOT Projects and Use Cases" and includes a note that "Matthew Pearson edited this page 7 days ago · 3 revisions". A bulleted list contains the item "Network Resiliency and Link Removal Tool". On the right side, there is a "Pages" sidebar with 4 pages listed: Home, Documentation and Scenario Datasets, FTOT Installation Guide, and FTOT Projects and Use Cases. At the bottom right, there is a section titled "Clone this wiki locally" with a text input field containing the URL `https://github.com/VolpeUSDOT/FTOT` and a copy icon.

Demo

The screenshot shows a GitHub repository page for 'dflynn-volpe / FTOT-Public-Link_Removal'. The repository is forked from 'VolpeUSDOT/FTOT-Public'. The current branch is 'master', which is 6 commits ahead and 4 commits behind 'VolpeUSDOT:master'. The file list includes:

File	Description	Time
..		
.ipynb_checkpoints	Update R packages for smaller footprint	29 days ago
__pycache__	Update R packages for smaller footprint	29 days ago
Calculate_Evenness_Compiled_Disruption.R	Completed readme, completed evenness calc notebook	29 days ago
Calculating_Evenness.ipynb	Adding R tools to render Markdown report	29 days ago
Conduct_Link_Removal.ipynb	Update R packages for smaller footprint	29 days ago
Disruption_Results.Rmd	Update R packages for smaller footprint	29 days ago
Disruption_Results.html	Update R packages for smaller footprint	29 days ago
README.md	Update README.md	6 hours ago
Rutil.R	Update R packages for smaller footprint	29 days ago
compile_report.R	Adding R tools to render Markdown report	29 days ago
compile_report.py	Update R packages for smaller footprint	29 days ago
environment.yml	Adding R tools to render Markdown report	29 days ago
ftot_networkx.py	Completed readme, completed evenness calc notebook	29 days ago
ftot_routing.py	Completed readme, completed evenness calc notebook	29 days ago

Demo

Documents/git/FTOT-Public/usecase/Conduct_Link_Removal - Jupyter Notebooklocalhost:8888

Conduct_Link_Removal - Jupyter Notebooklocalhost:8888

QuitLogout

FilesRunningClusters

Select items to perform actions on them.

0Documents / git / FTOT-Public / usecase / link_removal

NameLast ModifiedFile size

seconds ago

Calculating_Evenness.ipynbRunninga month ago21 kB

Conduct_Link_Removal.ipynbRunninga minute ago60.3 kB

BC_Disruption_Cost.jpg6 minutes ago142 kB

Calculate_Evenness_Compiled_Disruption.R4 months ago7.55 kB

compile_report.py6 minutes ago809 B

compile_report.Ra month ago127 B

Disruption_Results.html6 minutes ago4.75 MB

Disruption_Results.Rmd11 minutes ago3.77 kB

environment.ymla month ago5.52 kB

Evenness_Calcs.csv6 hours ago146 B

Evenness_Disruption_Fig.jpeg6 hours ago406 kB

One_Panel_Max_Pct_Change_4Evenness_Fig.jpeg6 hours ago281 kB

One_Panel_Pct_Change_Evenness_Disruption_Fig.jpeg6 hours ago281 kB

README.md4 hours ago2.02 kB

resiliency_disruptions.pya month ago11 kB

RoadLayer.RData6 hours ago160 MB

Rutil.Ra month ago725 B

Demo

Documents/git/FTOT-Public/usecase/... Conduct_Link_Removal - Jupyter New Tab dflynn-volpe/FTOT-Public-Link...

localhost:8888/notebooks/Documents/git/FTOT-Public/usecase/link_removal/Conduct_Link_Removal.ipynb

jupyter Conduct_Link_Removal Last Checkpoint: 2 minutes ago (unsaved changes)

File Edit View Insert Cell Kernel Help Trusted Python [conda env:FTOTenv] *

even 1/2

Sequential removal of links and resiliency testing

- Disruption of a network by removal of links, based on:
 - Sum of betweenness centrality of from and to nodes
 - Link length
 - Volume of commodity flow
- Calculation of performance in terms of cost and unmet demand by re-running disrupted network on FOT
- Plot link removal along x-axis and performance on y-axis, comparing networks of differing evenness. Dynamic report generated in an Rmarkdown automatically from this Notebook.

Assumptions

- Working in a Python 3.x environment for this notebook
 - Refer to the README in this repository for instructions on setup of all dependencies with `conda`
- Python 2.7 installed as part of ArcGIS
- 64 bit background geoprocessing enabled
- Access to ArcGIS license server if necessary

Reference

- [NetworkX Documentation](#)

```
In [5]: import pandas as pd
import geopandas as gpd
import sqlalchemy
import networkx as nx
import os
import matplotlib.pyplot as plt
import pickle

import resiliency_disruptions

# Uses Quick Start 7 as an example. Modify `scen_name` and `scen_path` for your scenario.
scen_name = 'qs7_rmp_proc_dest_multi_inputs'

scen_path = os.path.join("C:\\FTOT\\scenarios\\quick_start\\", scen_name)

chn_path = os.path.join(scen_path, 'temp_networkx_chn_files')
```

Demo

The screenshot shows a Jupyter Notebook interface in a web browser. The browser tabs include 'Documents/git/FTOT-Public/use...', 'Conduct_Link_Removal - Jupyter', 'New Tab', and 'dflynn-volpe/FTOT-Public-Link...'. The address bar shows 'localhost:8888/notebooks/Documents/git/FTOT-Public/usecase/link_removal/Conduct_Link_Removal.ipynb'. The Jupyter interface has a menu bar (File, Edit, View, Insert, Cell, Kernel, Help) and a toolbar with icons for file operations, running, and markdown. The notebook title is 'Conduct_Link_Removal' with a status 'Last Checkpoint: 2 minutes ago (unsaved changes)'. The environment is 'Python [conda env:FTOTenv]'. The notebook content includes a title 'Sequential removal of links and resiliency testing', a list of bullet points describing the process, assumptions, and a reference to NetworkX Documentation. Below the text is a code cell with Python imports and setup code.

Sequential removal of links and resiliency testing

- Disruption of a network by removal of links, based on:
 - Sum of betweenness centrality of from and to nodes
 - Link length
 - Volume of commodity flow
- Calculation of performance in terms of cost and unmet demand by re-running disrupted network on FOT
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Reference

- [NetworkX Documentation](#)

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scen_path = os.path.join("C:\\FTOT\\scenarios\\quick_start\\", scen_name)

chn_path = os.path.join(scen_path, 'temp_networkx_shp_files')
```

Demo

