A Comprehensive Decision Support Tool for Accelerated Bridge Construction Considering Safety, Social Equity, and Environmental Justice

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FIU FLORIDA INTERNATIONAL UNIVERSITY

ABC UTC IBT

Innovative Bridge Technologies/Accelerated Bridge Construction University Transportation Center

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Notes

- Go to the “Go to” section on the dashboard to access a pdf copy of this presentation.

- All the references, including the FIU-ABC tool and training videos, will be archived on the IBT/ABC-UTC website at the following link.

  https://abc-utc.fiu.edu/a-comprehensive-decision-support-tool-for-accelerated-bridge-construction-considering-safety-social-equity-and-environmental-justice/

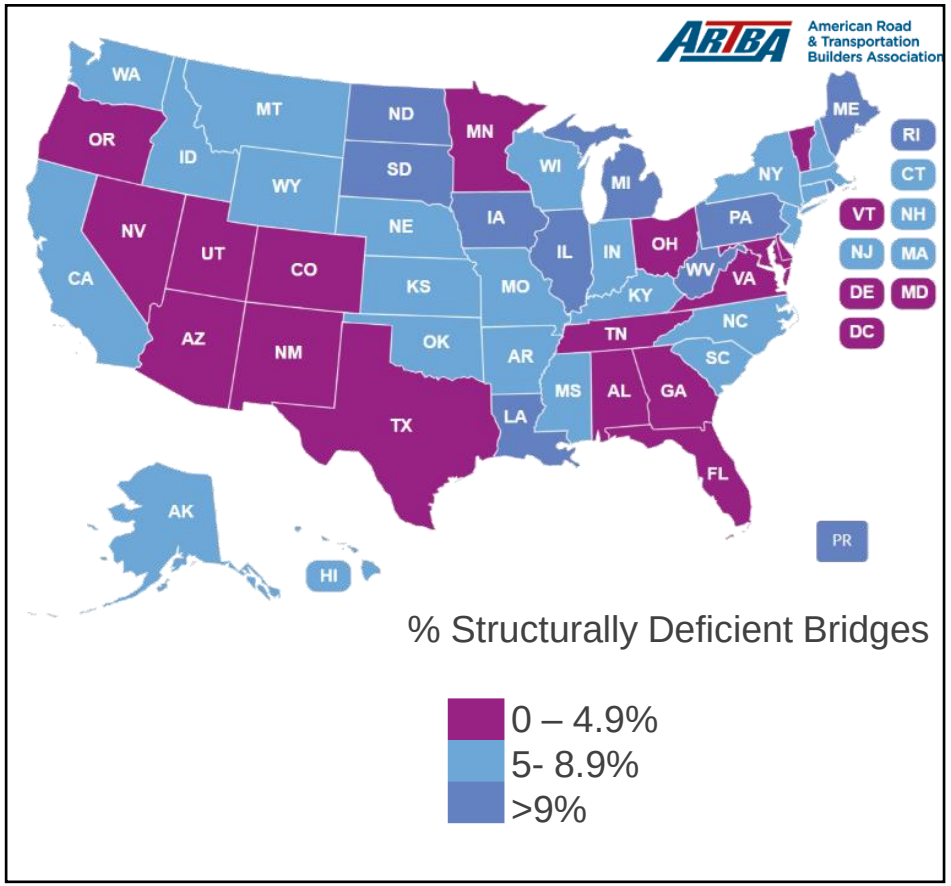
Problem Statement: Bridge Conditions in the U.S.

Importance:

- American Road & Transportation Builders Association (ARTBA) and National Bridge Inventory (NBI), 2023:
  - 1 out of 3 U.S. bridges needs repair or replacement.
  - Urgent need for effective bridge construction and renovation.

Constraints:

- **Limited budget and time**
  - Increasing number of bridges going from “good” to “fair” condition
  - Bridge constructions and rehabilitations are slow.
  - 75-year timeline for U.S. bridge repair at current pace.
  - Need to Accelerated Bridge Construction (ABC)
- **Challenges in decision-making**
  - Difficult prioritization and planning
  - Various decision criteria: Structural, traffic, site limitations, safety, social and environmental concerns.

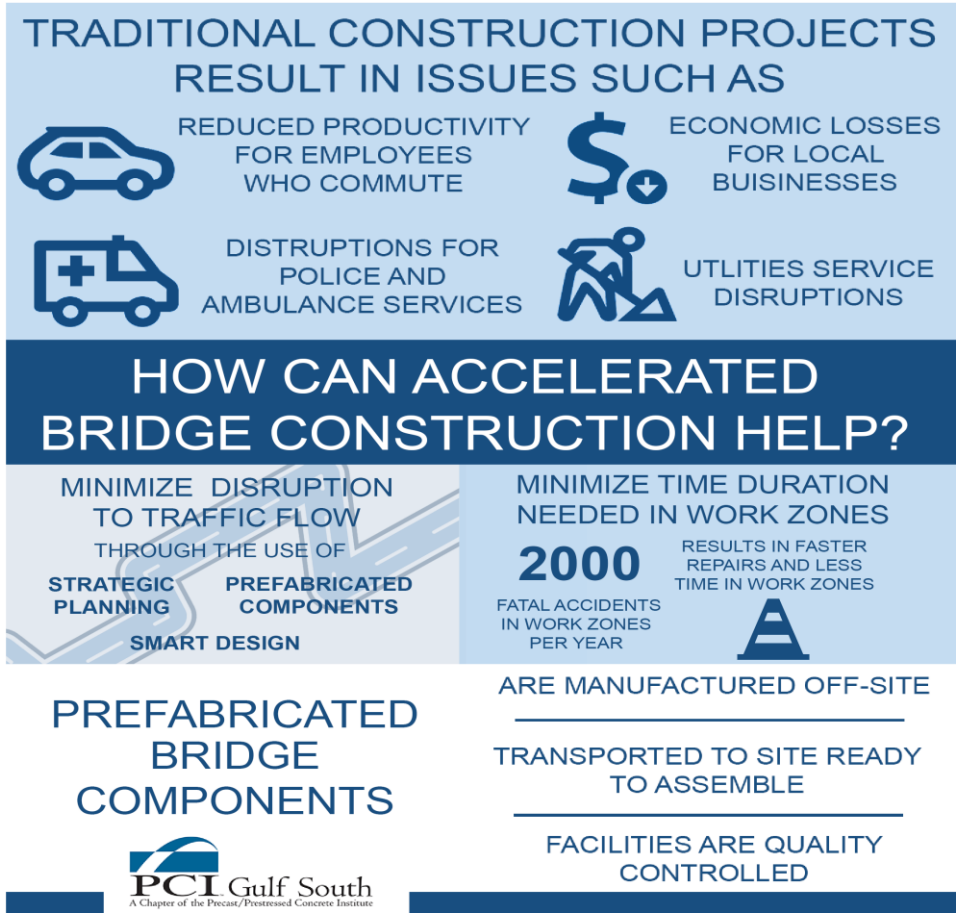


42,400 bridges are rated in poor condition and classified as “structurally deficient.” ARTBA, 2023

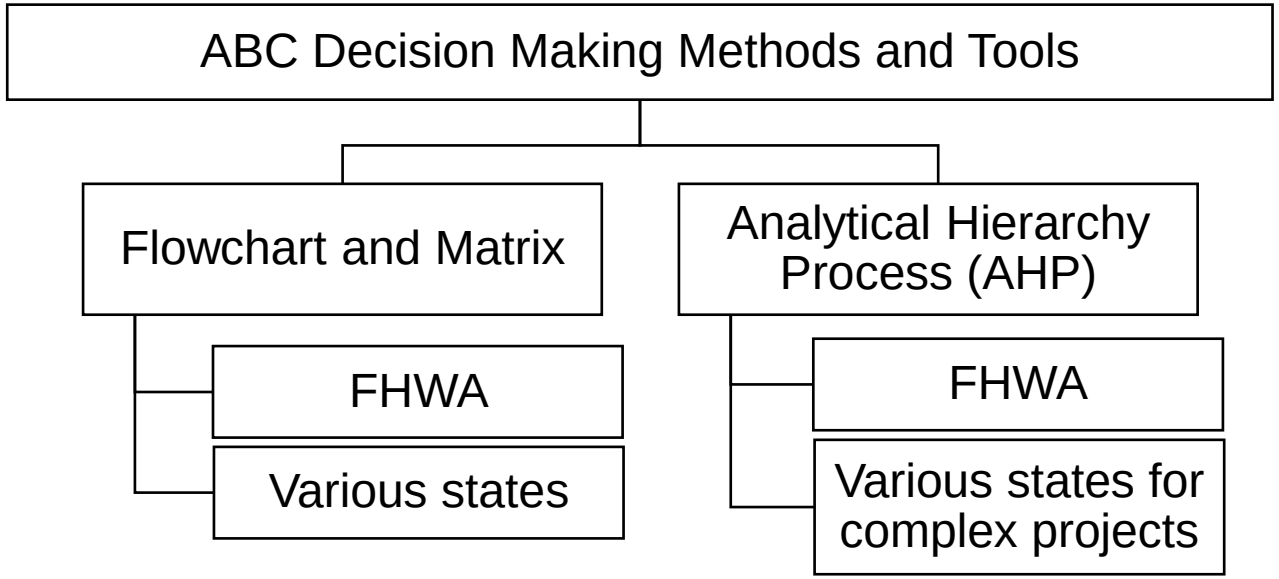
Problem Statement: Accelerated Bridge Construction (ABC)

ABC benefits according to FHWA:

- Improvements in:
  - Safety
  - Quality
  - Durability
  - Social Costs
  - Environmental Impacts



Existing ABC Decision-Making Methods/Tools



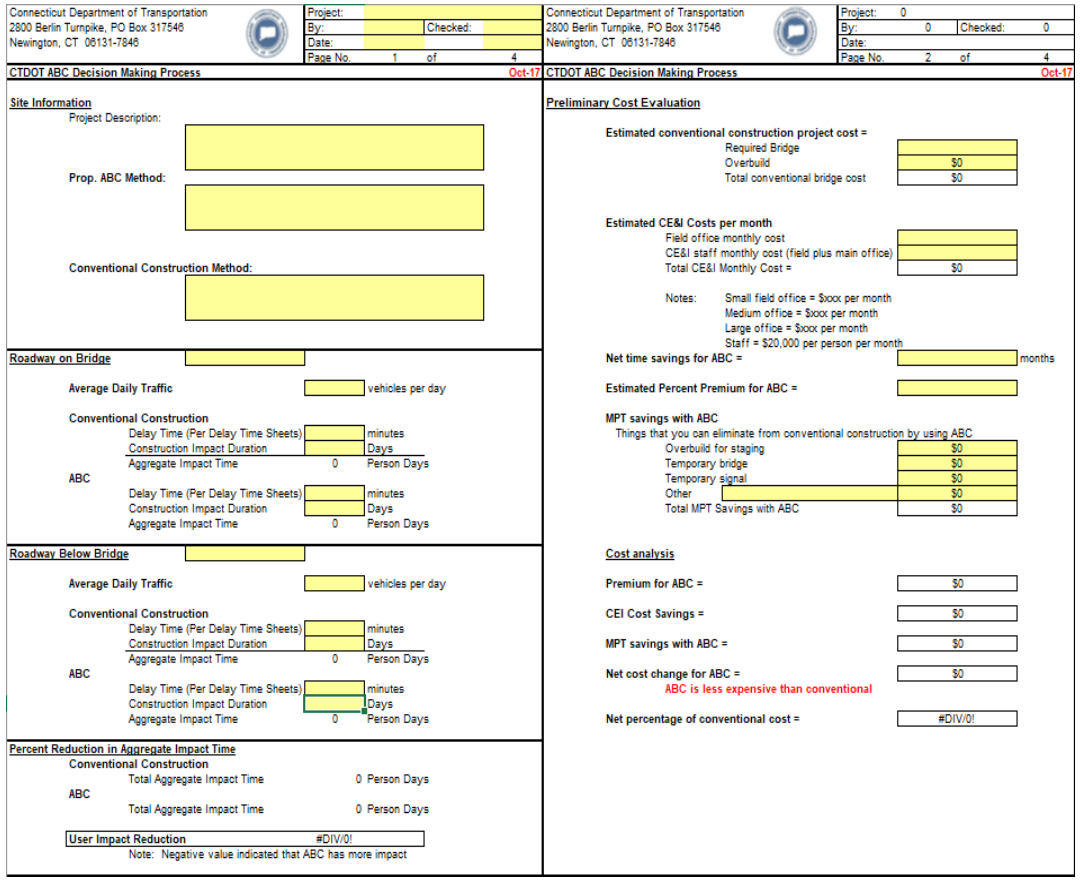
Link to FHWA Flowchart and Matrix Tool: https://www.fhwa.dot.gov/bridge/prefab/frameworkflowchart.cfm

Link to ABC AHP Decision Making Tool: https://www.fhwa.dot.gov/bridge/abc/fast.cfm

Connecticut

- Middle ground approach: relatively simple
- Develop a simplified road user impact process
- Account for total project costs
- Offset ABC costs with costs that can be reduced or eliminated with ABC

CTDOT ABC Decision Matrix Preview



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Date:
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CTDOT ABC Decision Making Process Oct-17

Site Information

Project Description:

Prop. ABC Method:

Conventional Construction Method:

Roadway on Bridge

Average Daily Traffic ____ vehicles per day

Conventional Construction
- Delay Time (Per Delay Time Sheets) ____ minutes
- Construction Impact Duration ____ Days
- Aggregate Impact Time 0 Person Days

ABC
- Delay Time (Per Delay Time Sheets) ____ minutes
- Construction Impact Duration ____ Days
- Aggregate Impact Time 0 Person Days

Roadway Below Bridge

Average Daily Traffic ____ vehicles per day

Conventional Construction
- Delay Time (Per Delay Time Sheets) ____ minutes
- Construction Impact Duration ____ Days
- Aggregate Impact Time 0 Person Days

ABC
- Delay Time (Per Delay Time Sheets) ____ minutes
- Construction Impact Duration ____ Days
- Aggregate Impact Time 0 Person Days

Percent Reduction in Aggregate Impact Time

Conventional Construction
- Total Aggregate Impact Time 0 Person Days

ABC
- Total Aggregate Impact Time 0 Person Days

User Impact Reduction #DIV/0!
Note: Negative value indicated that ABC has more impact

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CTDOT ABC Decision Making Process Oct-17

Preliminary Cost Evaluation

Estimated conventional construction project cost =
- Required Bridge
- Overbuild $0
- Total conventional bridge cost $0

Estimated CE&I Costs per month
- Field office monthly cost
- CE&I staff monthly cost (field plus main office)
- Total CE&I Monthly Cost = $0

Notes: Small field office = $xxx per month
Medium office = $xxx per month
Large office = $xxx per month
Staff = $20,000 per person per month

Net time savings for ABC = ____ months

Estimated Percent Premium for ABC = ____

MPT savings with ABC
Things that you can eliminate from conventional construction by using ABC
- Overbuild for staging $0
- Temporary bridge $0
- Temporary signal $0
- Other $0
- Total MPT Savings with ABC $0

Cost analysis

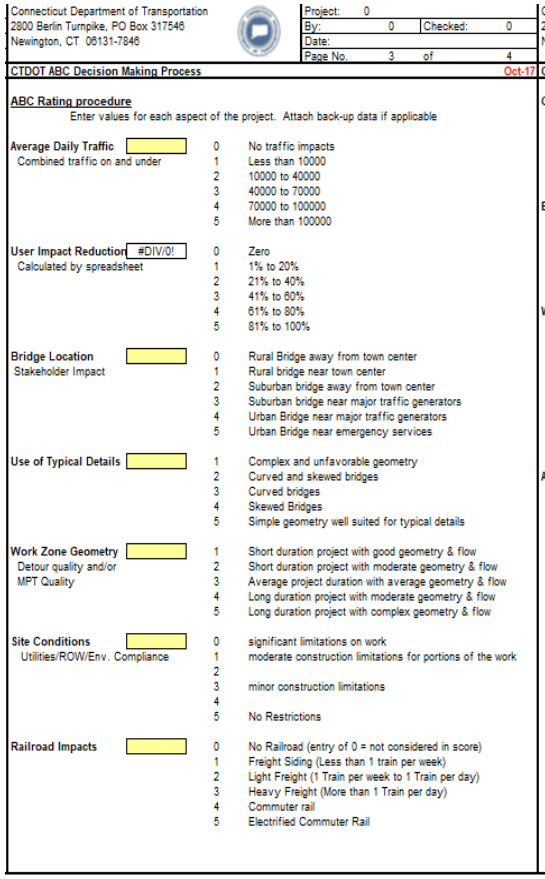
Premium for ABC = $0

CEI Cost Savings = $0

MPT savings with ABC = $0

Net cost change for ABC = $0
ABC is less expensive than conventional

Net percentage of conventional cost = #DIV/0!



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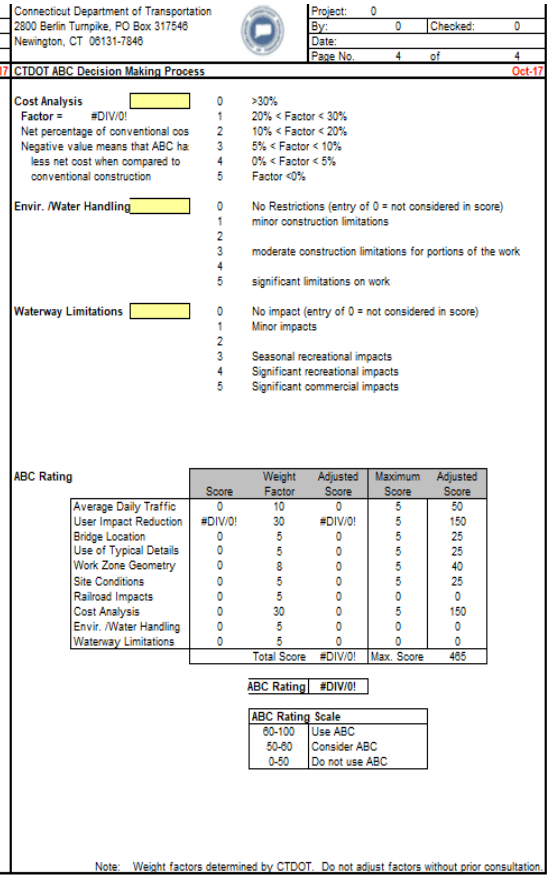
CTDOT ABC Decision Making Process Oct-17

ABC Rating procedure
Enter values for each aspect of the project. Attach back-up data if applicable

Average Daily Traffic ____ Combined traffic on and under	0	No traffic impacts
	1	Less than 10000
	2	10000 to 40000
	3	40000 to 70000
	4	70000 to 100000
	5	More than 100000
User Impact Reduction #DIV/0! Calculated by spreadsheet	0	Zero
	1	1% to 20%
	2	21% to 40%
	3	41% to 60%
	4	61% to 80%
	5	81% to 100%
Bridge Location ____ Stakeholder Impact	0	Rural Bridge away from town center
	1	Rural bridge near town center
	2	Suburban bridge away from town center
	3	Suburban bridge near major traffic generators
	4	Urban Bridge near major traffic generators
	5	Urban Bridge near emergency services
Use of Typical Details ____	1	Complex and unfavorable geometry
	2	Curved and skewed bridges
	3	Curved bridges
	4	Skewed Bridges
	5	Simple geometry well suited for typical details
Work Zone Geometry ____ Detour quality and/or MPT Quality	1	Short duration project with good geometry & flow
	2	Short duration project with moderate geometry & flow
	3	Average project duration with average geometry & flow
	4	Long duration project with moderate geometry & flow
	5	Long duration project with complex geometry & flow
Site Conditions ____ Utilities/ROW/Env. Compliance	0	significant limitations on work
	1	moderate construction limitations for portions of the work
	2	
	3	minor construction limitations
	4	
	5	No Restrictions
Railroad Impacts ____	0	No Railroad (entry of 0 = not considered in score)
	1	Freight Siding (Less than 1 train per week)
	2	Light Freight (1 Train per week to 1 Train per day)
	3	Heavy Freight (More than 1 Train per day)
	4	Commuter rail
	5	Electrified Commuter Rail



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Project: 0
By: 0 Checked: 0
Date:
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CTDOT ABC Decision Making Process Oct-17

Cost Analysis ____ Factor = #DIV/0! Net percentage of conventional cos Negative value means that ABC ha less net cost when compared to conventional construction	0	>30%
	1	20% < Factor < 30%
	2	10% < Factor < 20%
	3	5% < Factor < 10%
	4	0% < Factor < 5%
	5	Factor <0%
Envir. /Water Handling ____	0	No Restrictions (entry of 0 = not considered in score)
	1	minor construction limitations
	2	
	3	moderate construction limitations for portions of the work
	4	
	5	significant limitations on work
Waterway Limitations ____	0	No impact (entry of 0 = not considered in score)
	1	Minor impacts
	2	
	3	Seasonal recreational impacts
	4	Significant recreational impacts
	5	Significant commercial impacts

ABC Rating

	Score	Weight Factor	Adjusted Score	Maximum Score	Adjusted Score
Average Daily Traffic	0	10	0	5	50
User Impact Reduction	#DIV/0!	30	#DIV/0!	5	150
Bridge Location	0	5	0	5	25
Use of Typical Details	0	5	0	5	25
Work Zone Geometry	0	8	0	5	40
Site Conditions	0	5	0	5	25
Railroad Impacts	0	5	0	0	0
Cost Analysis	0	30	0	5	150
Envir. /Water Handling	0	5	0	0	0
Waterway Limitations	0	5	0	0	0
		Total Score	#DIV/0!	Max. Score	465

ABC Rating #DIV/0!

ABC Rating Scale	
60-100	Use ABC
50-60	Consider ABC
0-50	Do not use ABC

Note: Weight factors determined by CTDOT. Do not adjust factors without prior consultation.

CTDOT ABC Decision Matrix

10 Criteria

Predetermined (fixed) weights

Spreadsheet tool

Two alternatives:
1. ABC
2. Conventional (No ABC)

ABC Rating

	Score	Weight Factor	Adjusted Score	Maximum Score	Adjusted Score
Average Daily Traffic	0	10	0	5	50
User Impact Reduction	0	30	0	5	150
Bridge Location	0	5	0	5	25
Use of Typical Details	0	5	0	5	25
Work Zone Geometry	0	8	0	5	40
Site Conditions	0	5	0	5	25
Railroad Impacts	0	5	0	0	0
Cost Analysis	0	30	0	5	150
Envir. /Water Handling	0	5	0	0	0
Waterway Limitations	0	5	0	0	0
		Total Score	0	Max. Score	465

Final score for ABC

ABC Rating	0

Weighted Scoring Algorithm
(Simple Additive Weighting)

Decision support

ABC Rating Scale	
60-100	Use ABC
50-60	Consider ABC
0-50	Do not use ABC

Some Areas for Improvement of CTDOT Decision Matrix

1. Need for Additional Criteria (e.g., work zone safety, social equity, and environmental justice)

2. Systematic determination of relative importance (weights) of criteria

Objectives

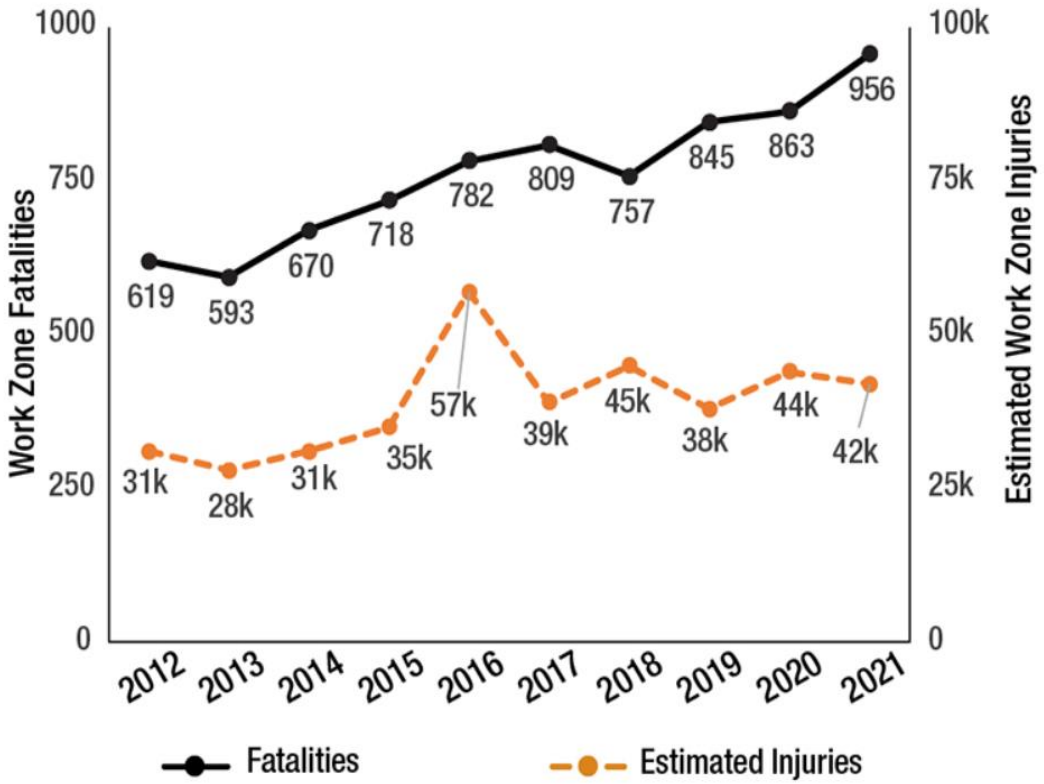
- Improve the Connecticut DOT ABC decision tool to obtain a more comprehensive and flexible decision support tool:
  - Quantify ABC benefits for work zone **safety** and incorporate it into the tool.
  - Incorporate **social equity** and **environmental justice** into the tool.
  - Incorporate a systematic method for determining the **relative importance (weights) of criteria** in the tool.

- The improved decision support tool should be:
  - Simple
  - Systematic (adjustable)
  - Readily available data
  - Capable of group decision making

ABC and Work Zone Safety

Work Zone Fatalities and Injuries:

- Work zone fatalities increased by %55 from 2012 to 2021.
  - An average of 2.6 persons per day lost their lives in work zones in 2021.
- Work zone injuries increased by % 35 from 2012 to 2021.
  - An average of 115 injuries per day in work zones in 2021.



National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS)

ABC and Social Equity

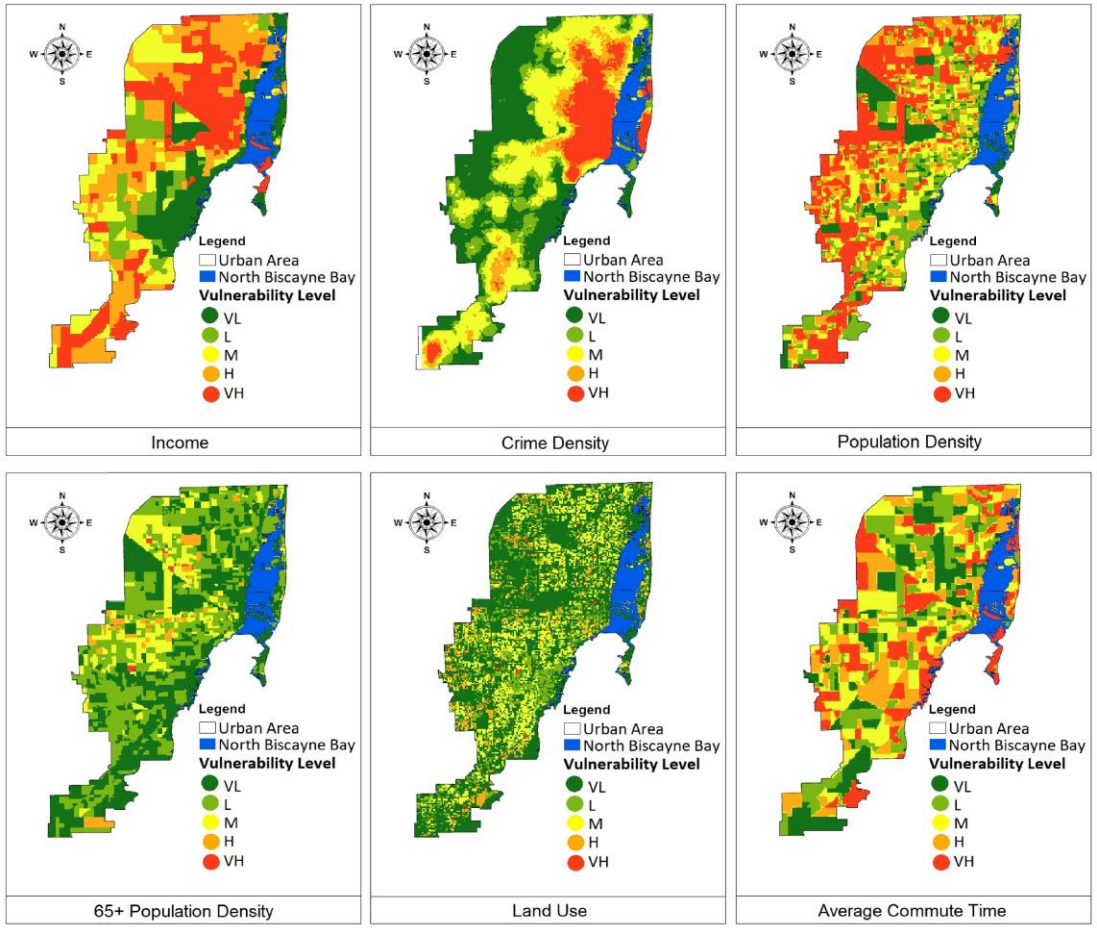
- **Social Equity in Urban Infrastructure Planning**
  - Providing equal resources and opportunities by infrastructure systems for all urban communities.
- **Incorporating social equity in urban infrastructure planning**
  - Elimination/reduction of disparate access to amenities and services among different community groups, including ethnic minorities, low-income groups, the elderly, etc.
- **ABC Benefits:**
  - Minimized interruptions in accessing vital resources and amenities (Hospitals, Schools, etc.) for vulnerable communities.
  - Facilitate emergency responses, especially in underserved communities (Research has shown that these communities are disproportionately impacted by natural hazards such as hurricanes and floods).
  - Reduced risk of vandalism/theft of construction equipment and materials, ensuring a more secure construction environment.
    - Reduce construction insurance costs
    - Reduce construction delays due to legal investigations

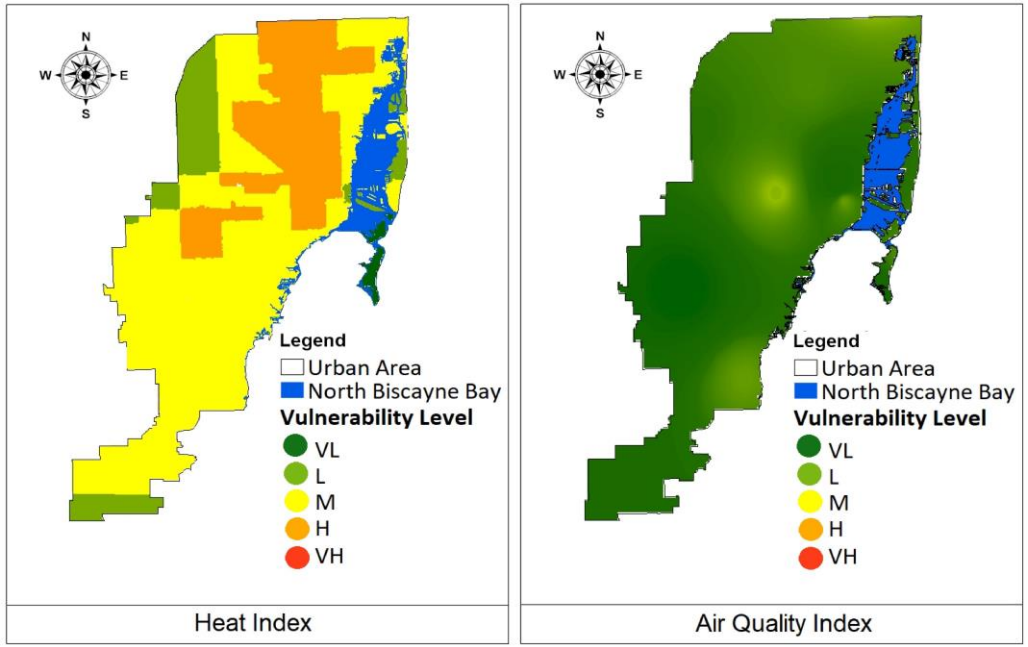
ABC and Environmental Justice

- **Environmental Justice**
  - Fair treatment and involvement of all people regarding environmental policies.
- **Incorporating environmental justice in urban infrastructure planning**
  - Providing same degree of protection from environmental and health hazards for everyone (including the construction workers and people living close to work zones)
- **ABC Benefits:**
  - Reduced workforce exposure to environmental threats such as extreme heat or poor air quality.
    - Effects of air quality and extreme heat on human health.
    - Threat to workers and urban communities adjacent to the project.
    - Worker's health issues can further impact the construction speed and cost.

Example of Incorporating Social Equity and Environmental Justice into the Prioritization of Bridge Construction Projects

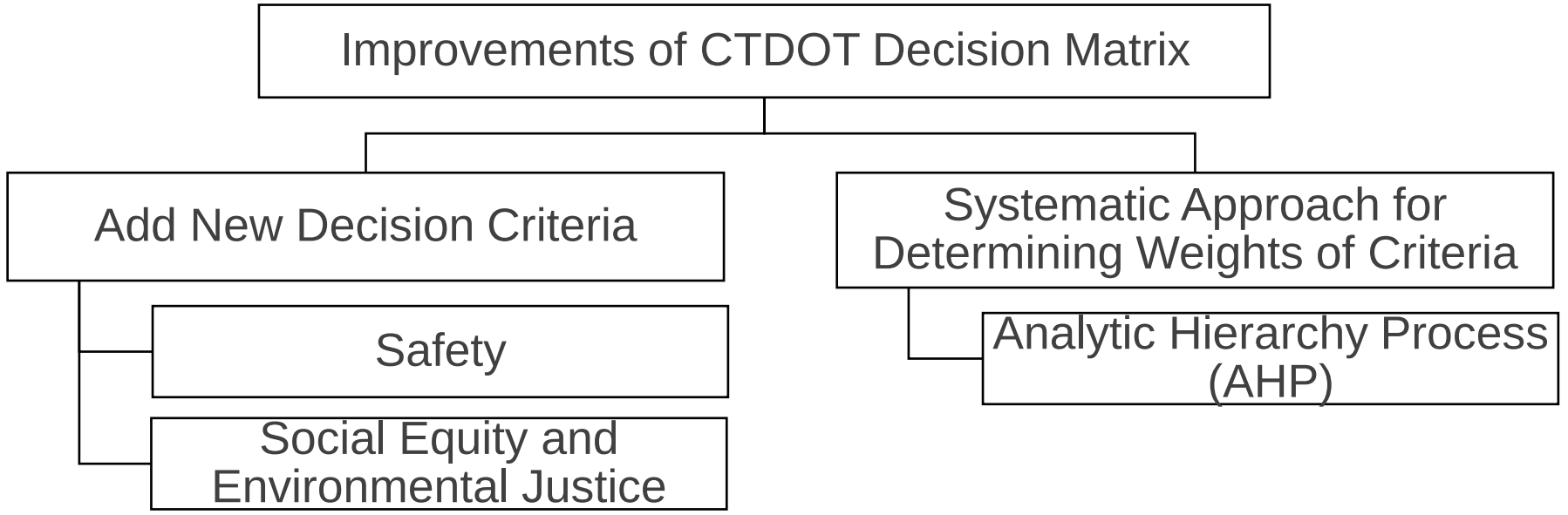
Our recent work: a vulnerability-based decision support framework





N. Mohamadiazar, A. Ebrahimian, and A. Azizinamini, 2024, Equitable Prioritization of Bridge Rehabilitation Projects Using a Spatial Multi-Criteria Decision Support Framework, TRR, https://doi.org/10.1177/03611981241254110

Methodology



- ✓ First time incorporation of quantified ABC benefits for improving work zone safety in ABC decision making.
- ✓ First time incorporation of social equity and environmental justice in ABC decision making.

FIU ABC Decision Support Tool Overview

- The FIU ABC tool is still spreadsheet (excel) based with the same format as CTDOT tool.
- New tabs are added.

Link to the tool and training videos:
https://abc-utc.fiu.edu/a-comprehensive-decision-support-tool-for-accelerated-bridge-construction-considering-safety-social-equity-and-environmental-justice/

Methodology: Safety Benefit Quantification

- By comparing the crash costs associated with each construction approach, decision-makers can better understand the safety advantages offered by ABC over traditional methods.

$$Safety\ Benefit = \frac{X * Cost\ of\ crashes\ per\ lane\ closure\ day\ (work\ zone)}{Cost\ of\ ABC\ implementation - Cost\ of\ conventional\ method\ implementation}$$

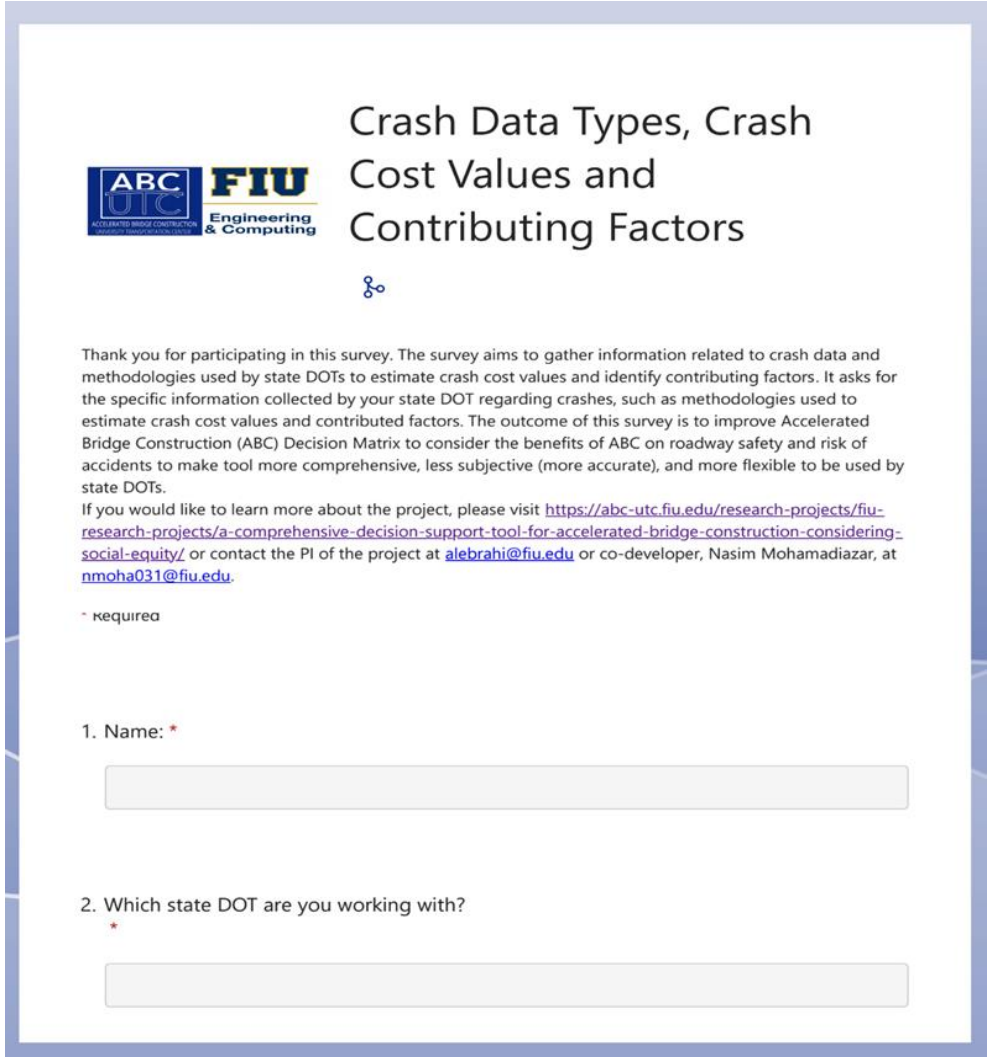
X = the number of days reduced in the work zone duration due to ABC

- This project builds on and leverages the findings of past ABC-UTC projects and associated PhD research works:
  - Work Zone Safety Analysis, Investigating Benefits from Accelerated Bridge Construction (ABC) on Roadway Safety (ABC-UTC-2016-C3-FIU03).
  - Mokhtarimousavi (2020), Work Zone Safety Analysis, Investigating Benefits from Accelerated Bridge Construction (ABC) On Roadway Safety, PhD Dissertation in Civil Engineering, FIU
  - Integrated Flood and Socio-Environmental Risk Analysis for Prioritizing ABC Activities (ABC-UTC-2016-C4-FIU05)

Survey about Crash Data at state DOTs

To effectively quantify the safety benefits in the FIU ABC Tool a limited survey was conducted.

- **Purpose of the Survey:**
  - To understand how different state DOTs handle their data associated with crashes frequency, severity, and unit cost.
- **Outcomes:**
  - lack of uniformity and consistencies in crash data gathering and reporting across states.
- **Application of the Survey:**
  - Ensuring different state DOTs can effectively use the safety tab.



Crash Data Types, Crash Cost Values and Contributing Factors

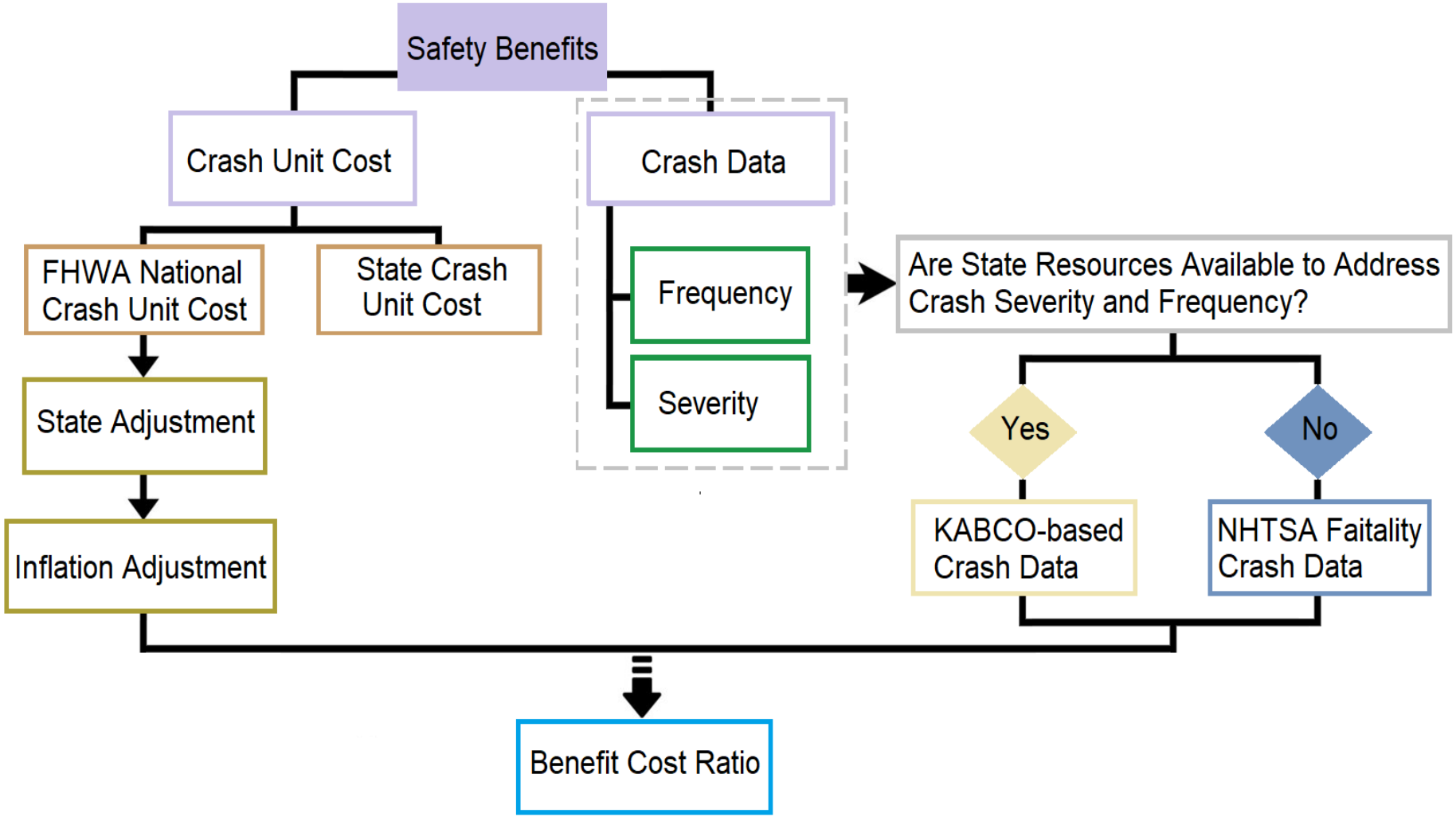
Thank you for participating in this survey. The survey aims to gather information related to crash data and methodologies used by state DOTs to estimate crash cost values and identify contributing factors. It asks for the specific information collected by your state DOT regarding crashes, such as methodologies used to estimate crash cost values and contributed factors. The outcome of this survey is to improve Accelerated Bridge Construction (ABC) Decision Matrix to consider the benefits of ABC on roadway safety and risk of accidents to make tool more comprehensive, less subjective (more accurate), and more flexible to be used by state DOTs.
If you would like to learn more about the project, please visit https://abc-utc.fiu.edu/research-projects/fiu-research-projects/a-comprehensive-decision-support-tool-for-accelerated-bridge-construction-considering-social-equity/ or contact the PI of the project at alebrahi@fiu.edu or co-developer, Nasim Mohamadiazar, at nmoha031@fiu.edu.

* Required

1. Name: *

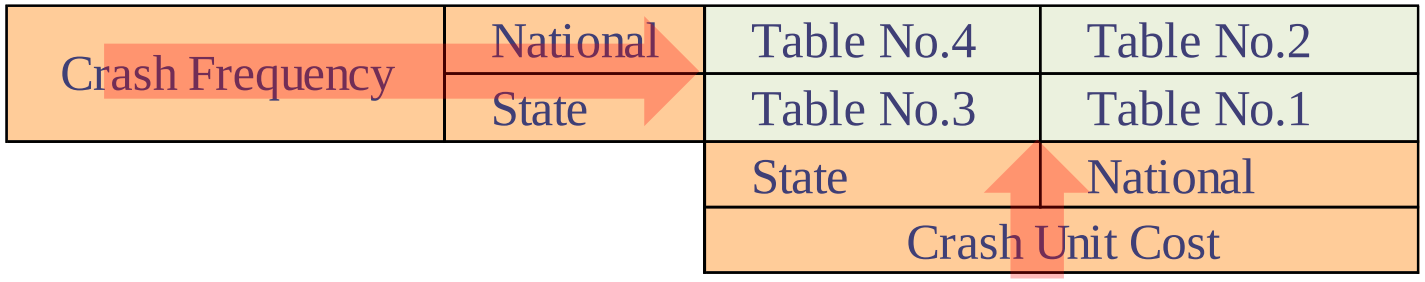
2. Which state DOT are you working with? *

Methodology: Safety Benefit-Cost Analysis



FIU ABC Decision Support Tool: Safety Benefits

- To effectively use the "Safety" tab, start by identifying the available data:
  - Choose the appropriate table number from the matrix.
  - Users need to complete only one of the Tables.

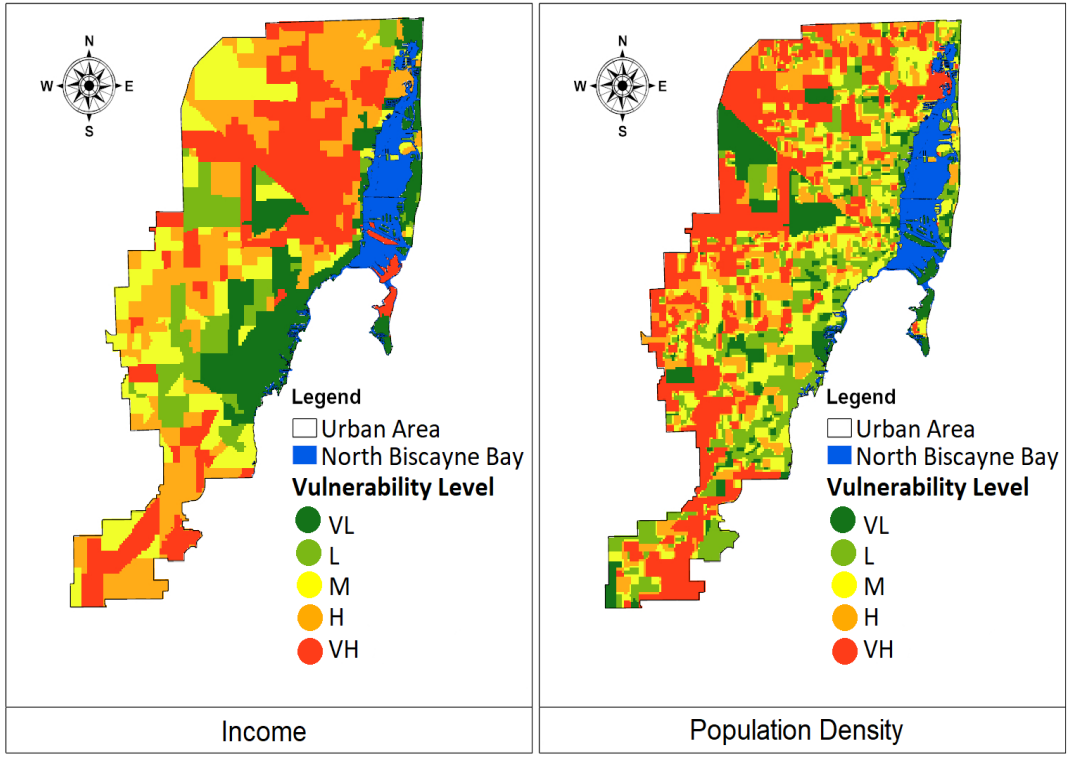


Data Link:

National Highway Traffic Safety Administration (NHTSA)	https://cdan.dot.gov/stsi.htm#
Per Capita Income (PCI)	https://apps.bea.gov/itable/
Consumer Price Index (CPI)	https://www.bls.gov/regions/mid-atlantic/data/

Social Equity

- To keep the tool simple, we only used the following data:
  - Population density
  - Per capita income

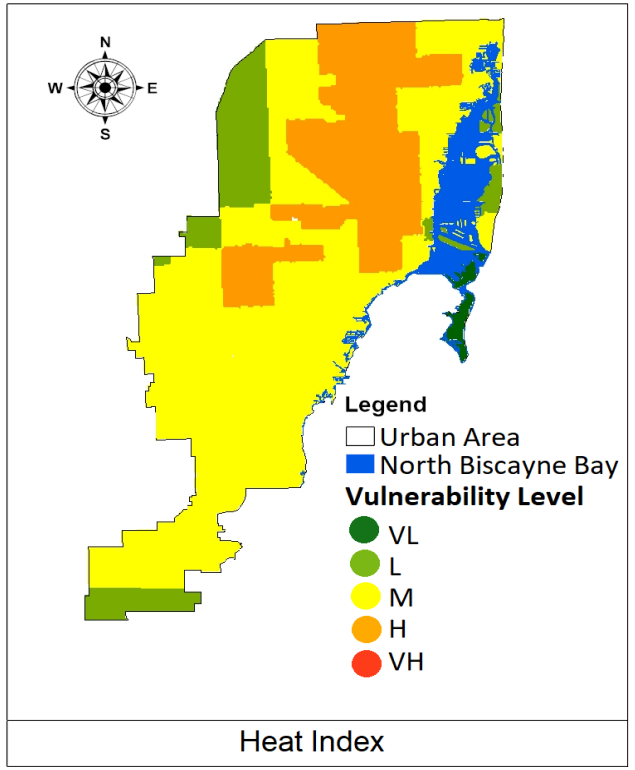


Population density and income in urban areas of Miami-Dade County, FL

Mohamadiazar et al. 2024. TRR

Environmental Justice

- Indicator related to Environmental Justice:
  - Heat/Wind Chill Index



Heat index in urban areas of Miami-Dade County, FL

Mohamadiazar et al. 2024. TRR

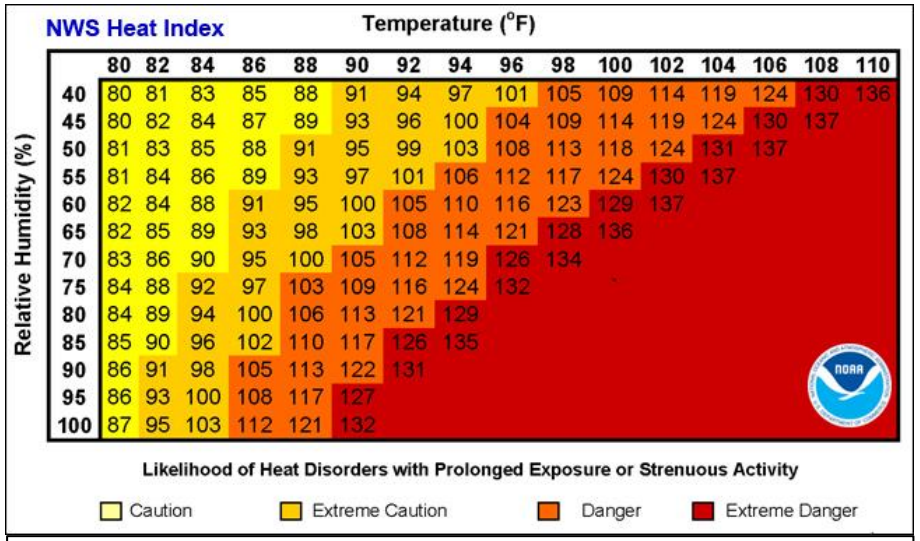
Environmental Justice

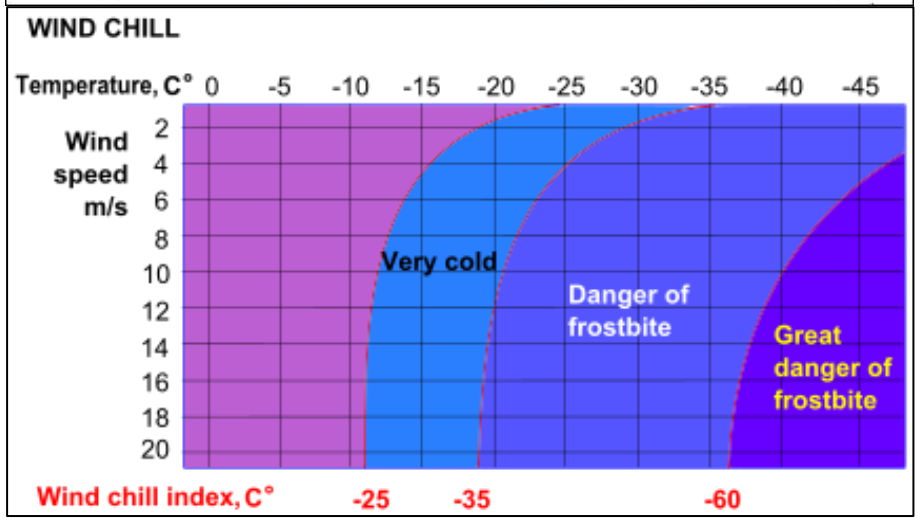
Heat Index?

- Known as the apparent temperature, is what the temperature feels like to the human body when **relative humidity** is combined with the **air temperature.**

Wind Chill Index?

- The wind chill temperature is based on the rate of heat loss from exposed skin caused by **wind and cold** and is to give you an approximation of how cold the air feels on your body.





SEEJ Index

- Social Equity and Environmental Justice (SEEJ) Index
- Average of scores for each SEEJ factor (population density, income, and heat/wind chill index)

$$SEEJ\ Index = \frac{0.5(Population\ density\ score + Income\ score) + Heat\ or\ Chill\ index\ score}{2}$$

FIU ABC Decision Support Tool: Relative Weights of Criteria

- Two primary methods are included to determine the relative weights of criteria:
  - Predetermined Weights
  - Analytical Hierarchy Process (AHP) Weights

- The tool includes two tables, each designated for one of the methods:
  - Table No. 1 for Predetermined Weights
  - Table No. 2 for AHP Weights

- Users need to complete only one of the Tables.

Instructions to Determine Relative Weights of Criteria:

To determine the relative importance (weights) of the given criteria in this decision support tool, there are two primary methods: 1) predetermined weights by decsion makers and 2) using the Analytical Hierarchy Process (AHP) method. Below is a guideline for each method.
Note: Users need to complete only one of the Tables: No. 1 or No. 2.

Guidelines:

Table No. 1: Predetermined Weights
Assign a weight factor to each criterion based on expert judgment or organizational priorities. The following Table is just an example of predetermined weights. The weights for each case should be determined by relevant decsion makers.

Examples of predetermined weights

Criterion	Predetermined Weights Example
Average Daily Traffic	10
User Impact Reduction	30
Bridge Location	5
Use of Typical Details	5
Work Zone Geometery	8
Site Conditions	5
Railroad Impacts	5
Cost Analysis	30
Envir./Water Handeling	5
Waterway Limitations	5
Safety	30
SEEJ Index	20

Table No. 2: Using AHP for dedermining weights
Compare each criterion with every other criterion based on the follwoing 1-9 scales and enter values in yellow cells.

Note: If the consistency ratio is greater than 0.10, user should change the paiwise comparison values so the consistency ratio falls below 0.10.

AHP scales for comparison (Saaty, 1980)

Intensity of Importance	Definition
1	Equal importance
3	Somewhat more important
5	Much more important
7	Very much more important
9	More important
2, 4, 6, 8	Intermediate values

Relative Weights of Criteria: Predetermined Weights

- Users should assign a weight factor to each criterion based on expert judgment or organizational priorities.
- There are examples of predetermined weights available within the tool.

Created by:		Checked by:	
Date:		Date:	
Table No.	1	of	2

Predetermined Weights

Criterion	Predetermined Weights
Average Daily Traffic	
User Impact Reduction	
Bridge Location	
Use of Typical Details	
Work Zone Geometery	
Site Conditions	
Railroad Impacts	
Cost Analysis	
Envir./Water Handeling	
Waterway Limitations	
Safety	
SEEJ Index	

Relative Weights of Criteria: Analytic Hierarchy Process (AHP)

- AHP works based on a pairwise comparison of criteria on a scale of 1-9.
- Users should:
  - compare each criterion with every other criterion to determine their relative importance on a scale of 1-9.
  - enter preference values in specified yellow cells.

AHP comparison scales (Saaty, 1980)

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgement slightly favour one over the other.
5	Much more important	Experience and judgement strongly favour one over the other.
7	Very much more important	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important.	The evidence favouring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed

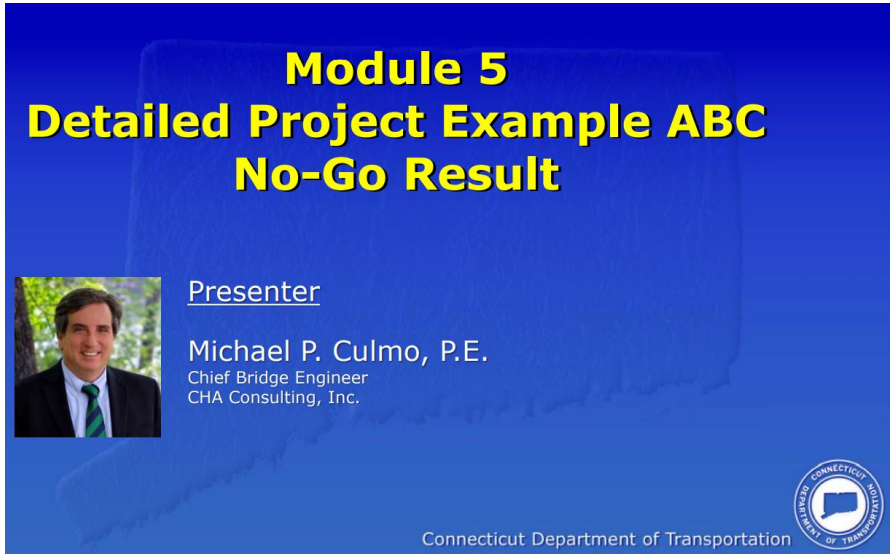
Created by:	Nasim	Checked by:	
Date:	Tuesday, July 9, 2024	Date:	
Table No.	2	of	2

Analytical Hierarchy Process (AHP) Weights

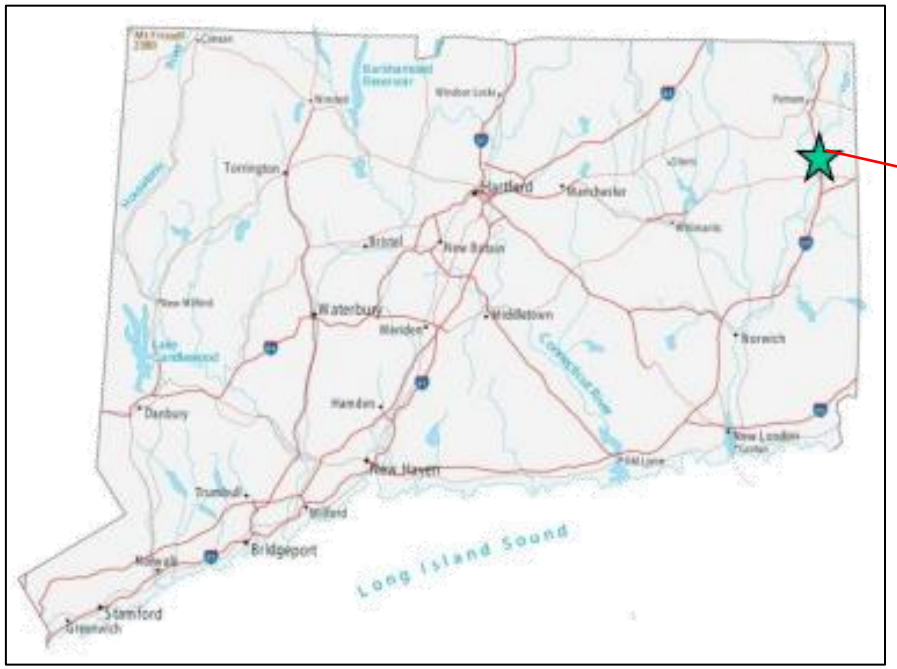
Criterion	Average Daily Traffic	User Impact Reduction	Bridge Location	Use of Typical	Work Zone Geometery	Site Conditions	Railroad Impacts	Cost Analysis	Envir./Water Handeling	Waterway Limitations	Safety	SEEJ Index	Weight
Average Daily Traffic	1												
User Impact Reduction		1											
Bridge Location			1										
Use of Typical Details				1									
Work Zone Geometery					1								
Site Conditions						1							
Railroad Impacts							1						
Cost Analysis								1					
Envir./Water Handeling									1				
Waterway Limitations										1			
Safety											1		
SEEJ Index												1	

Case Study: Replacement of Bridge 03469, I-395 NB over Tracy Road in Killingly

- To compare the existing and improved tool, we evaluated the performance in a project in CT titled “DOT Project No. 0068-0211”.
- We used the same exact input information to compare the outcomes from the tools.
- The presentation was conducted by Michael P. Culmo as part of the ABC-UTC 2021 In-Depth Web Training (See module 5 at the following link)
- https://abc-utc.fiu.edu/mc-events/development-and-implementation-of-the-connecticut-dot-abc-program/



Case Study: Project Location



Located in Eastern Connecticut:
– Town of Killingly
– Interstate I-395 over Tracey Road

Case Study: Project Scope

- Non-ABC Construction: Staged construction
  - Maintain 2 lanes in Stage 1
  - 1 Lane in Stage 2
  - Construction time: **18 months**
  - Closure time: N/A

- ABC Construction
  - Close road and detour traffic
  - Build GRS-IBS abutment before closure
  - Replace superstructure using modular deck beam units
  - Construction time: **12 months**
  - Closure time: 7 days

Beam End Deterioration

Base Calculations

AQ15 | fx | 1

Created by:	Nasim	Checked by:	
Date:	Wednesday, July 10, 2024	Date:	
Table No.	1	of	4
Roadway on Bridge:	I-395		
Average Daily Traffic:	16000	Vehicles per Day	
Conventional Construction			
Delay Time:	1.60	Minutes	
Construction Impact Duration:	75	Days	
Aggregate Impact Time	1333	Person Days	
ABC			
Delay Time:	14.70	Minutes	
Construction Impact Duration:	7	Days	
Aggregate Impact Time	1143	Person Days	
Roadway below Bridge:	Tracey Road		
Average Daily Traffic:	3000	Vehicles per Day	
Conventional Construction			
Delay Time:	0.10	Minutes	
Construction Impact Duration:	550	Days	
Aggregate Impact Time	115	Person Days	
ABC			
Delay Time:	8.20	Minutes	
Construction Impact Duration:	7	Days	
Aggregate Impact Time	120	Person Days	
Percent Reduction in Aggregate Impact Time			
Conventional Construction			
Total Aggregate Impact Time	1448	Person Days	
ABC			
Total Aggregate Impact Time	1263	Person Days	
User Impact Reduction	13%		

Created by:	Nasim	Checked by:	
Date:	Wednesday, July 10, 2024	Date:	
Table No.	2	of	4
Preliminary Cost Evaluation			
Estimated Conventional Construction Project Cost			
Required Bridge:		$ 5,000,000.00	
Overbuild:		$ -	
Total Conventional Bridge Cost		$ 5,000,000.00	
Estimated CE&I Costs per Month			
Field Office Monthly Cost:		$ 5,000.00	
CE&I Staff Monthly Cost (Field Plus Main Office):		$ 40,000.00	
Total CE&I Monthly Cost		$ 45,000.00	
Notes:	Small field office = $xxx per month		
	Medium office = $xxx per month		
	Large office = $xxx per month		
	Staff = $20,000 per person per month		
Net Time Savings for ABC:		6.00	Months
Estimated Percent Premium for ABC:		15%	
MPT Savings with ABC			
(Things that you can eliminate from conventional construction by using ABC)			
Overbuild for Staging:		$ -	
Temporary Bridge:		$ -	
Temporary Signal:		$ -	
Other:		$ 75,000.00	
Total MPT Savings with ABC		$ 75,000.00	
Cost Analysis			
Premium for ABC		$ 750,000.00	
CEI Cost Savings		$ 270,000.00	
MPT Savings with ABC		$ 75,000.00	

Base Calculations | Safety Instruction | Safety | SEEJ Index Instruction | SEEJ Index | Weight Assignment Instruction | Weights | Results

ABC UTC IBT

FIU Engineering & Computing

Case Study: User Impact Reduction

Roadway on Bridge	I-395	
Average Daily Traffic	16000	vehicles per day
Conventional Construction		
Delay Time (Per Delay Time Sheets)	1.60	minutes
Construction Impact Duration	75	Days
Aggregate Impact Time	1333	Person Days
ABC		
Delay Time (Per Delay Time Sheets)	14.70	minutes
Construction Impact Duration	7	Days
Aggregate Impact Time	1143	Person Days

Roadway Below Bridge	Tracey Road	
Average Daily Traffic	3000	vehicles per day
Conventional Construction		
Delay Time (Per Delay Time Sheets)	0.10	minutes
Construction Impact Duration	550	Days
Aggregate Impact Time	115	Person Days
ABC		
Delay Time (Per Delay Time Sheets)	8	minutes
Construction Impact Duration	7	Days
Aggregate Impact Time	120	Person Days

Number of days reduced due to ABC = (550+75)-(7+7) = 611 days

Percent Reduction in Aggregate Impact Time

Conventional Construction	
Total Aggregate Impact Time	1448 Person Days
ABC	
Total Aggregate Impact Time	1263 Person Days
User Impact Reduction	13%

Note: Negative value indicated that ABC has more impact

Case Study: Cost Analysis

Preliminary Cost Evaluation

Estimated conventional construction project cost =

Required Bridge	$5,000,000
Overbuild	$0
Total conventional bridge cost	$5,000,000

Estimated CE&I Costs per month

Field office monthly cost	$5,000
CE&I staff monthly cost (field plus main office)	$40,000
Total CE&I Monthly Cost =	$45,000

Net time savings for ABC =	6.0	months
Estimated Percent Premium for ABC =	15%	

MPT savings with ABC

Things that you can eliminate from conventional construction by using ABC

Overbuild for staging		
Temporary bridge		$0
Temporary signal		$0
Other	Temporary Barriers on I-395	$75,000
Total MPT Savings with ABC		$75,000

Cost analysis

Premium for ABC =	$750,000
CEI Cost Savings =	$270,000
MPT savings with ABC =	$75,000
Net cost change for ABC =	$405,000
ABC is more expensive than conventional	
Net percentage of conventional cost =	8%

Case Study: ABC Rating Scoring Using the CTDOT Decision Matrix

ABC Rating

	Score	Weight Factor	Adjusted Score	Maximum Score	Adjusted Score
Average Daily Traffic	2	10	20	5	50
User Impact Reduction	1	30	30	5	150
Bridge Location	1	5	5	5	25
Use of Typical Details	4	5	20	5	25
Work Zone Geometry	3	8	24	5	40
Site Conditions	3	5	15	5	25
Railroad Impacts	0	5	0	0	0
Cost Analysis	3	30	90	5	150
Envir. /Water Handling	0	5	0	0	0
Waterway Limitations	0	5	0	0	0
		Total Score	204	Max. Score	465

This is the Original Score from the CTDOT ABC Decision Matrix

ABC Rating	44

ABC Rating Scale	
60-100	Use ABC
50-60	Consider ABC
0-50	Do not use ABC

Safety

Instructions for Safety Calculations:

Users should follow the step-by-step guidelines for the safety calculation tables. Depending on what crash frequency and crash unit cost data is available (national or state), only one table (No. 1, 2, 3, or 4) needs to be completed based on the provided matrix. In case of using crash unit cost and/or crash frequency from national data, the guidlines below should be followed. Otherwise, the state data will be eused.

Matrix for Table Selection

Crash Frequency	National	Table No.4	Table No.2
	State	Table No.3	Table No.1
		State	National
		Crash Unit Cost	

Guidelines for Using National Data:

Access Crash Frequency Data from National Highway Traffic Safety Administration (NHTSA) Website:
- Access the NHTSA crash data website by clicking the link provided in the "Safety Instructions" tab.
- Once on the website, locate and select the "View USA Crash Location Map" option.
- Search for the Project Location.
- Turn on the crash location features under the crash fatal data on the NHTSA map.
- Count the dots you see on the map for each year separately.

Access Per Capita Income Data:
- Access the Bureau of Economic Analysis website by clicking the link provided in the "Safety Instructions" tab.
- Once on the website, locate and select the "Area/Statistic" option.
- Select the state where your project is located.
- Click "Next Step".
- Specify the year for which you need the Per Capita Income data.
- Click "Next Step".
- Copy the PCI value.
- Repeat these steps for every three selected years.

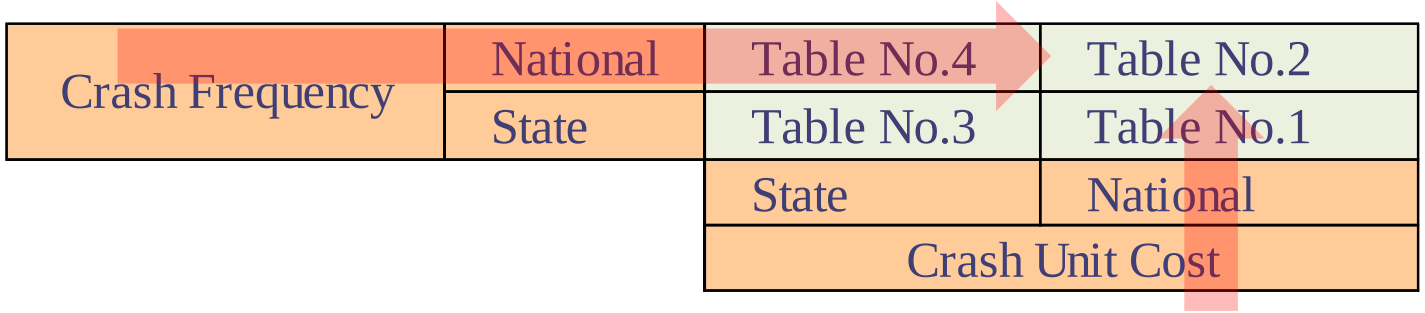
Access Consumer Price Index Data:
- Click the link provided in the "Safety Instructions" tab to access the U.S. Bureau of Labor Statistics website.
- Once on the website, copy the Consumer Price Index for the specific year, listed under "U.S. city average - Annual average".
- Repeat these steps for every three selected years.

Data Link

National Highway Traffic Safety Administration (NHTSA	https://cdan.dot.gov/
Per Capita Income (PCI)	https://apps.bea.gov/
Consumer Price Index (CPI)	https://www.bls.gov/

Case Study: Safety Benefits

- To effectively use the "Safety" tab, start by identifying the available data:
  - Assumption: Using National Data Bases



Data Link:

National Highway Traffic Safety Administration (NHTSA)	https://cdan.dot.gov/stsi.htm#
Per Capita Income (PCI)	https://apps.bea.gov/itable/
Consumer Price Index (CPI)	https://www.bls.gov/regions/mid-atlantic/data/

FIU ABC Decision Support Tool: Safety Benefits

State Crash Frequency Data and Applied FHWA National Unit Cost

Created by:		Checked by:				
Date:		Date:				
Table No.	1	of	4			

Selected Year-1

			State per Capita Income (PCI)		PCI Ratio	0.000
			Consumer Price Index (CPI)		PCI (2016)	$59,729
Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A	$ 655,000.00	$ -	$ -		
Non-incapacitating injury	B	$ 198,500.00	$ -	$ -		
Possible injury	C	$ 125,600.00	$ -	$ -		
Property damage only	O	$ 11,900.00	$ -	$ -		
			Total	$ -		

Selected Year-2

			State per Capita Income (PCI)		PCI Ratio	0.000
			Consumer Price Index (CPI)		PCI (2016)	$ 48,971.00
Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A	$ 655,000.00	$ -	$ -		
Non-incapacitating injury	B	$ 198,500.00	$ -	$ -		
Possible injury	C	$ 125,600.00	$ -	$ -		
Property damage only	O	$ 11,900.00	$ -	$ -		
			Total	$ -		

Selected Year-3

			State per Capita Income (PCI)		PCI Ratio	0.000
			Consumer Price Index (CPI)		PCI (2016)	$ 48,971.00
Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A	$ 655,000.00	$ -	$ -		
Non-incapacitating injury	B	$ 198,500.00	$ -	$ -		
Possible injury	C	$ 125,600.00	$ -	$ -		
Property damage only	O	$ 11,900.00	$ -	$ -		
			Total	$ -		

Three-year average	$	-
Per day crash unit cost	$	-
Saved construction days	$	68.00
Cost diff.	$	405,000.00
Safety Benefits		0%

National Crash Frequency Data and Applied FHWA National Unit Cost

Created by:		Checked by:				
Date:		Date:				
Table No.	2	of	4			

Selected Year-1

			State per Capita Income (PCI)		PCI Ratio	0.000
			Consumer Price Index (CPI)		PCI (2016)	$ 48,971.00
Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A					
Non-incapacitating injury	B					
Possible injury	C					
Property damage only	O					
			Total	$ -		

Selected Year-2

			State per Capita Income (PCI)		PCI Ratio	0.000
			Consumer Price Index (CPI)		PCI (2016)	$ 48,971.00
Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A					
Non-incapacitating injury	B					
Possible injury	C					
Property damage only	O					
			Total	$ -		

Selected Year-3

			State per Capita Income (PCI)		PCI Ratio	0.000
			Consumer Price Index (CPI)		PCI (2016)	$ 48,971.00
Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A					
Non-incapacitating injury	B					
Possible injury	C					
Property damage only	O					
			Total	$ -		

Three-year average	$	-
Per day crash unit cost	$	-
Saved construction days	$	68.00
Cost diff.	$	405,000.00
Safety Benefits		0%

Safety Benefits: Crash Frequency

- Access NHTSA crash data website by clicking the link provided in the “Safety Instructions” tab.

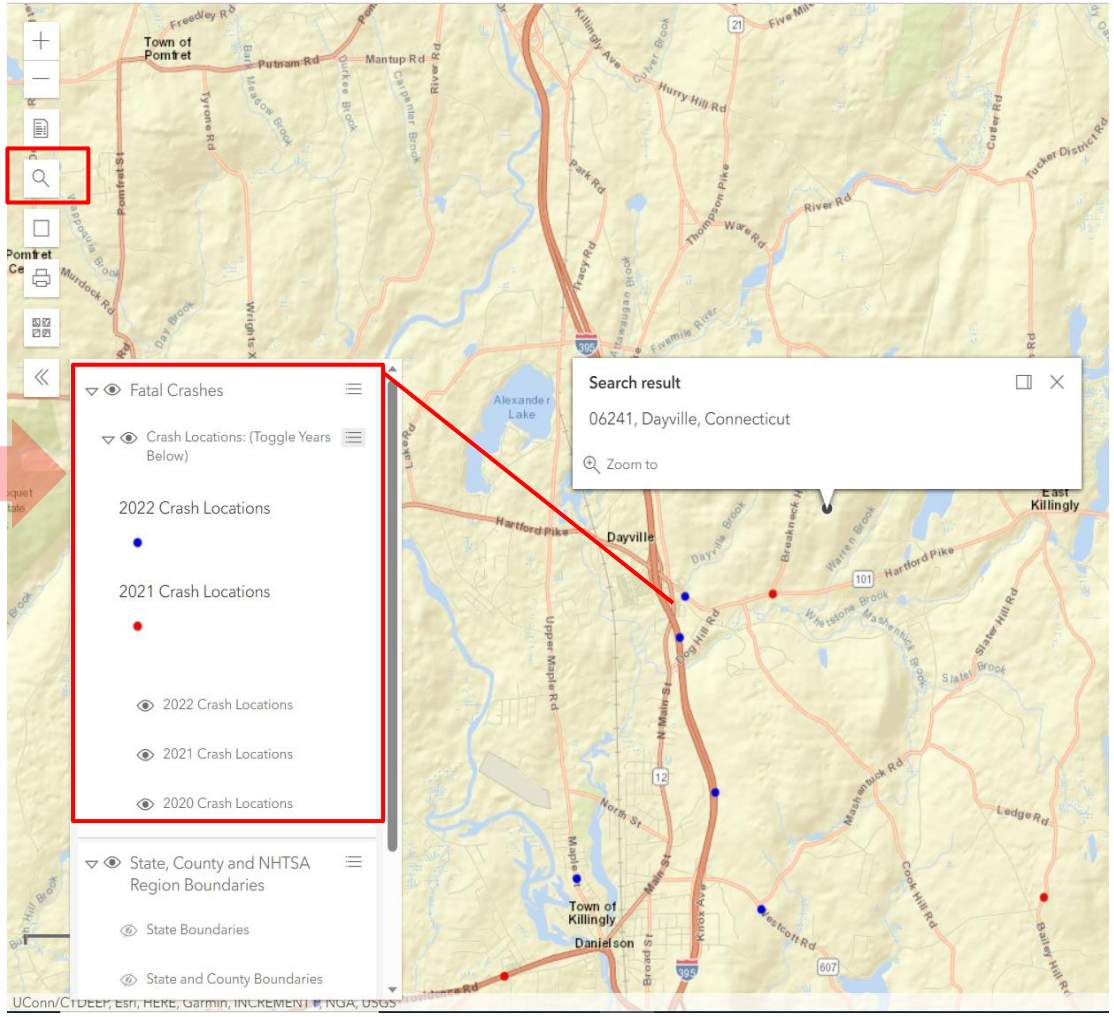
- Once on the website, locate and select the "View USA Crash Location Map" option.

Data Link:

National Highway Traffic Safety Administration (NHTSA)	https://cdan.dot.gov/stsi.htm#

FIU ABC Decision Support Tool: Crash Frequency

- Search for the location of your project (for this case study: zip code = 06241).
- Turn on the crash location features under crash fatal data and then count the dots you see on the map for each year separately.



Safety Benefits: Crash Frequency

- Enter the counted crash frequency into the corresponding yellow cells for each year (in this case study: Table No. 2 of Safety tab).

National Crash Frequency Data and Applied FHWA National Unit Cost

Created by:	Nasim		Checked by:			
Date:	Tuesday, July 9, 2024		Date:			
Table No.	2		of	4		

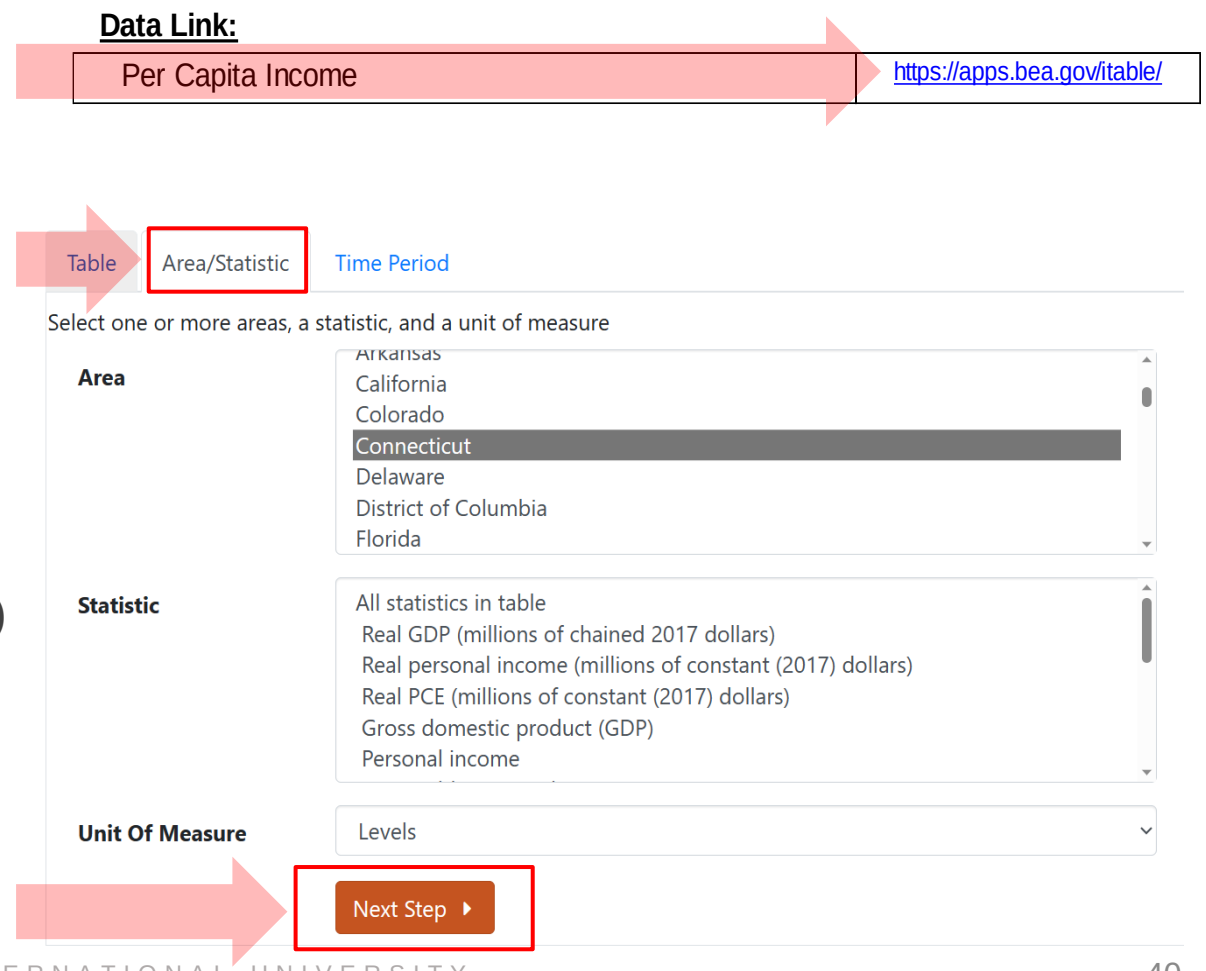
Selected Year-1	2020		State per Capita Income (PCI)	$	PCI Ratio	1.589
			Consumer Price Index (CPI)		PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	3	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A					
Non-incapacitating injury	B					
Possible injury	C					
Property damage only	O					
				Total	$ -	

Selected Year-2	2021		State per Capita Income (PCI)	$	PCI Ratio	1.657
			Consumer Price Index (CPI)		PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	3	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A					
Non-incapacitating injury	B					
Possible injury	C					
Property damage only	O					
				Total	$ -	

Selected Year-3	2022		State per Capita Income (PCI)	$	PCI Ratio	1.702
			Consumer Price Index (CPI)		PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	2	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A					
Non-incapacitating injury	B					
Possible injury	C					
Property damage only	O					
				Total	$ -	

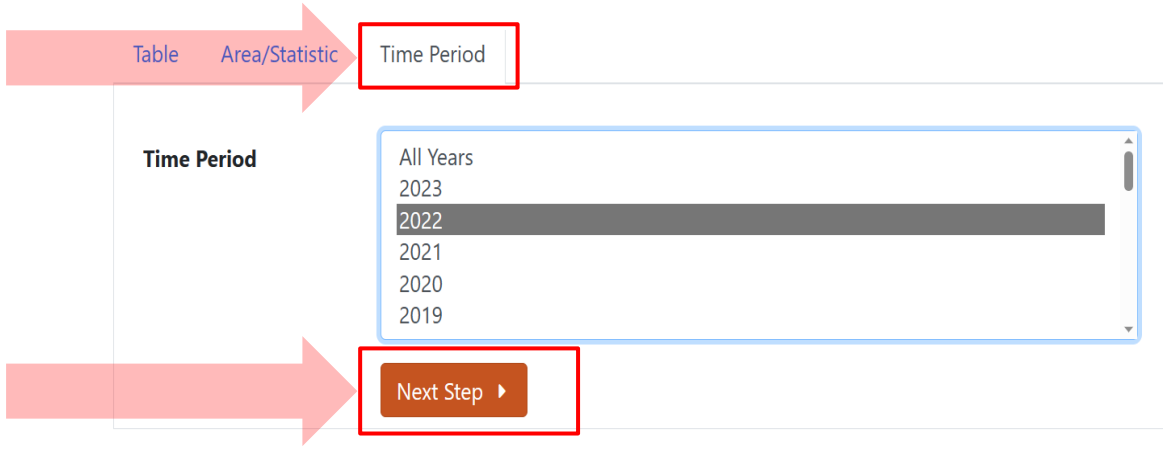
Safety Benefits: Crash Unit Cost

- Access Bureau of Economic Analysis website by clicking the link provided in the “Safety Instructions” tab.
- Once on the website, locate and select the “Area/Statistic" option, and then select the state where your project is located (in this case study: Connecticut)
- Click “Next Step”.



Safety Benefits: Crash Unit Cost

- Specify the year for which you need the PCI data (in this case study: 2020, 2021, 2022)
- Click "Next Step“.
- Copy the PCI value.
- Repeat these steps for every three selected years.



GeoFips	GeoName	2022
09000	Connecticut	83,340

Safety Benefits: Crash Unit Cost

- Enter the PCI values into the corresponding yellow cells for each year (in this case study: Table No. 2 of Safety tab).

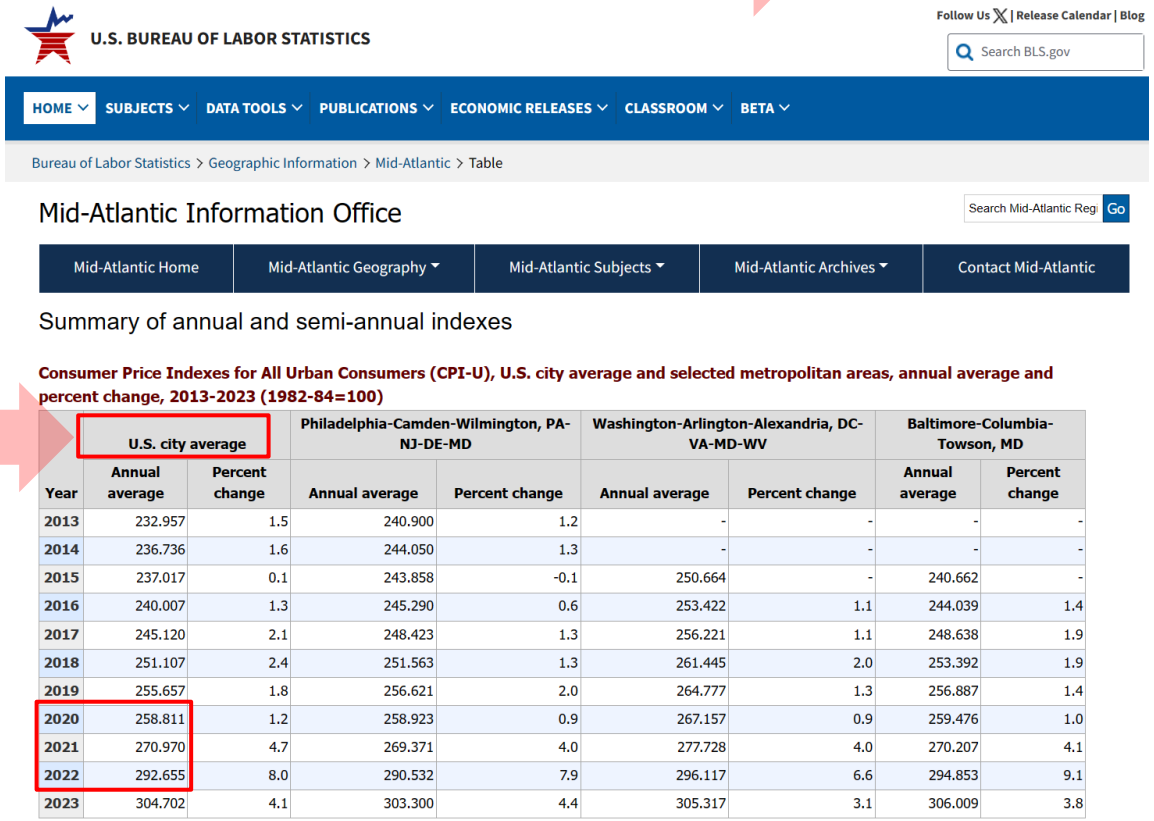
National Crash Frequency Data and Applied FHWA National Unit Cost							
Created by:	Nasim			Checked by:			
Date:	Tuesday, July 9, 2024			Date:			
Table No.	2			of	4		
Selected Year-1	2020		State per Capita Income (PCI)		$ 77,810.00	PCI Ratio	1.589
			Consumer Price Index (CPI)			PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	3	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A						
Non-incapacitating injury	B						
Possible injury	C						
Property damage only	O						
				Total	$ -		
Selected Year-2	2021		State per Capita Income (PCI)		$ 81,131.00	PCI Ratio	1.657
			Consumer Price Index (CPI)			PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	3	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A						
Non-incapacitating injury	B						
Possible injury	C						
Property damage only	O						
				Total	$ -		
Selected Year-3	2022		State per Capita Income (PCI)		$ 83,340.00	PCI Ratio	1.702
			Consumer Price Index (CPI)			PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	2	$11,295,402.00	$ -	$ -	CPI Ratio	0.000
Incapacitating injury	A						
Non-incapacitating injury	B						
Possible injury	C						
Property damage only	O						
				Total	$ -		

FIU-ABC Decision Support Tool: Crash Unit Cost

- Access the U.S. Bureau of Labor Statistics website by clicking the link provided in the “Safety Instructions” tab.
- Once on the website, copy CPI for the specific year, under "U.S. city average - Annual average”.
- Repeat these steps for every three selected years (in this case study: 2020, 2021, 2022).

Data Link:

National Highway Traffic Safety Administration (NHTSA) https://cdan.dot.gov/stsi.htm#



	U.S. city average		Philadelphia-Camden-Wilmington, PA-NJ-DE-MD		Washington-Arlington-Alexandria, DC-VA-MD-WV		Baltimore-Columbia-Towson, MD	
Year	Annual average	Percent change	Annual average	Percent change	Annual average	Percent change	Annual average	Percent change
2013	232.957	1.5	240.900	1.2	-	-	-	-
2014	236.736	1.6	244.050	1.3	-	-	-	-
2015	237.017	0.1	243.858	-0.1	250.664	-	240.662	-
2016	240.007	1.3	245.290	0.6	253.422	1.1	244.039	1.4
2017	245.120	2.1	248.423	1.3	256.221	1.1	248.638	1.9
2018	251.107	2.4	251.563	1.3	261.445	2.0	253.392	1.9
2019	255.657	1.8	256.621	2.0	264.777	1.3	256.887	1.4
2020	258.811	1.2	258.923	0.9	267.157	0.9	259.476	1.0
2021	270.970	4.7	269.371	4.0	277.728	4.0	270.207	4.1
2022	292.655	8.0	290.532	7.9	296.117	6.6	294.853	9.1
2023	304.702	4.1	303.300	4.4	305.317	3.1	306.009	3.8

Safety Benefits: Crash Unit Cost

- Enter the CPI values into the corresponding yellow cells for each year (in this case study: Table No. 2 of Safety tab).

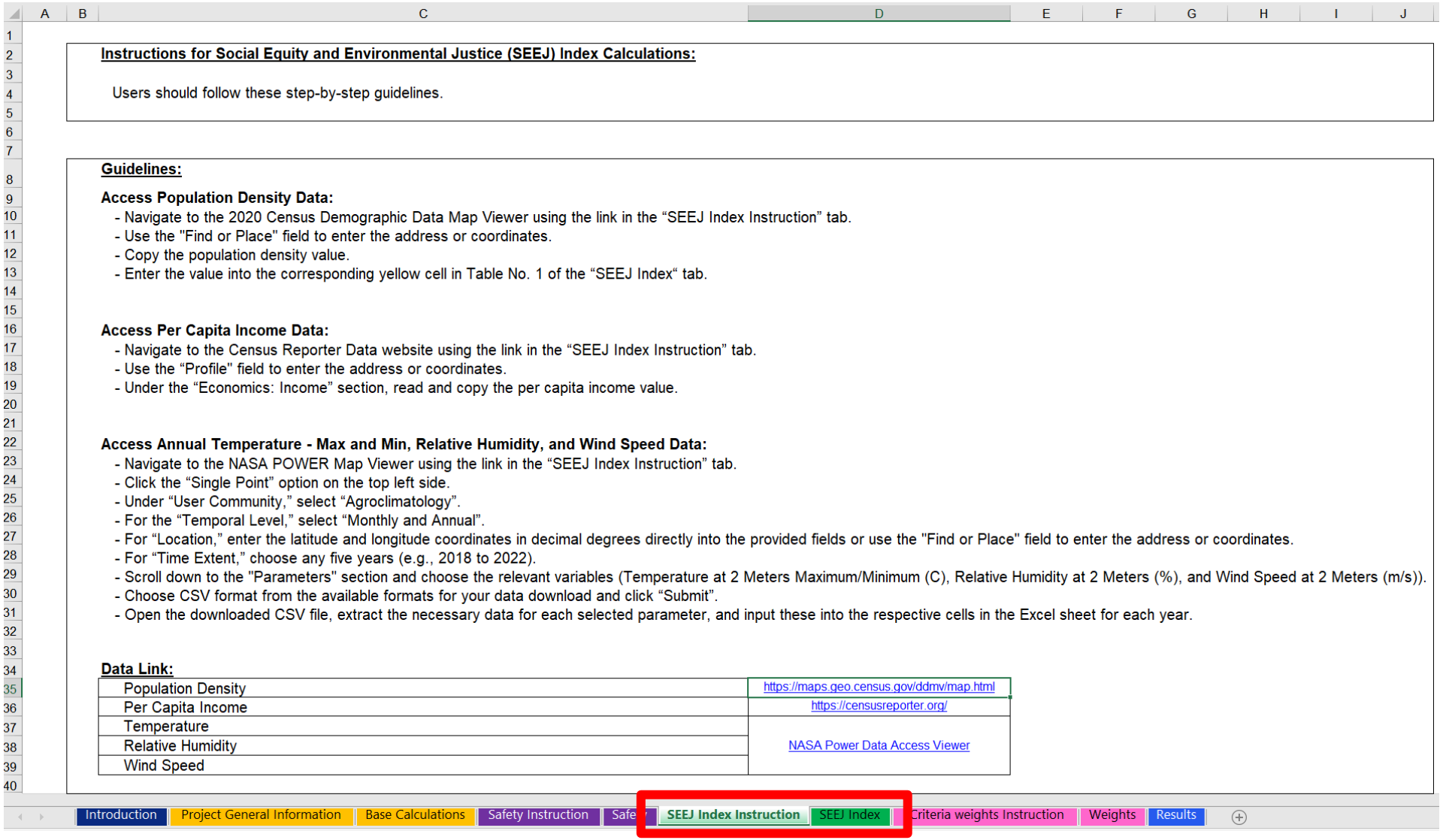
$$Safety\ Benefit = \frac{X * Cost\ of\ crashes\ per\ day\ (work\ zone)}{Cost\ of\ ABC\ implementation - Cost\ of\ conventional\ method\ implementation}$$

National Crash Frequency Data and Applied FHWA National Unit Cost

Created by:	Nasim			Checked by:			
Date:	Wednesday, July 10, 2024			Date:			
Table No.	2			of	4		
Selected Year-1	2020		State per Capita Income (PCI)		$ 77,810.00	PCI Ratio	1.589
			Consumer Price Index (CPI)		258.811	PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	3	$11,295,402.00	$ 19,353,385.93	$58,060,157.80	CPI Ratio	1.078
Incapacitating injury	A						
Non-incapacitating injury	B						
Possible injury	C						
Property damage only	O						
				Total	$58,060,157.80		
Selected Year-2	2021		State per Capita Income (PCI)		$ 81,131.00	PCI Ratio	1.657
			Consumer Price Index (CPI)		270.97	PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	3	$11,295,402.00	$21,127,438.75	$63,382,316.25	CPI Ratio	1.129
Incapacitating injury	A						
Non-incapacitating injury	B						
Possible injury	C						
Property damage only	O						
				Total	$63,382,316.25		
Selected Year-3	2022		State per Capita Income (PCI)		$ 83,340.00	PCI Ratio	1.702
			Consumer Price Index (CPI)		292.655	PCI (2016)	$ 48,971.00
	Severity	Frequency	National (2016)	State Adjusted	Total Cost	CPI (2016)	240.007
Fatal injury	K	2	$11,295,402.00	$23,439,495.26	$46,878,990.53	CPI Ratio	1.219
Incapacitating injury	A						
Non-incapacitating injury	B						
Possible injury	C						
Property damage only	O						
				Total	$46,878,990.53		
Three-year average					$		56,107,154.86

Per day crash unit cost	$ 275,485.21
Saved construction days	$ 68.00
Cost diff.	$ 405,000.00
Safety Benefits	62%

SEEJ Index



Instructions for Social Equity and Environmental Justice (SEEJ) Index Calculations:

Users should follow these step-by-step guidelines.

Guidelines:

Access Population Density Data:

- Navigate to the 2020 Census Demographic Data Map Viewer using the link in the “SEEJ Index Instruction” tab.
- Use the "Find or Place" field to enter the address or coordinates.
- Copy the population density value.
- Enter the value into the corresponding yellow cell in Table No. 1 of the “SEEJ Index“ tab.

Access Per Capita Income Data:

- Navigate to the Census Reporter Data website using the link in the “SEEJ Index Instruction” tab.
- Use the “Profile" field to enter the address or coordinates.
- Under the “Economics: Income” section, read and copy the per capita income value.

Access Annual Temperature - Max and Min, Relative Humidity, and Wind Speed Data:

- Navigate to the NASA POWER Map Viewer using the link in the “SEEJ Index Instruction” tab.
- Click the “Single Point” option on the top left side.
- Under “User Community,” select “Agroclimatology”.
- For the “Temporal Level,” select “Monthly and Annual”.
- For “Location,” enter the latitude and longitude coordinates in decimal degrees directly into the provided fields or use the "Find or Place" field to enter the address or coordinates.
- For “Time Extent,” choose any five years (e.g., 2018 to 2022).
- Scroll down to the "Parameters" section and choose the relevant variables (Temperature at 2 Meters Maximum/Minimum (C), Relative Humidity at 2 Meters (%), and Wind Speed at 2 Meters (m/s)).
- Choose CSV format from the available formats for your data download and click “Submit”.
- Open the downloaded CSV file, extract the necessary data for each selected parameter, and input these into the respective cells in the Excel sheet for each year.

Data Link:

Population Density	https://maps.geo.census.gov/ddmv/map.html
Per Capita Income	https://censusreporter.org/
Temperature	NASA Power Data Access Viewer
Relative Humidity	
Wind Speed	

Introduction | Project General Information | Base Calculations | Safety Instruction | Safe | SEEJ Index Instruction | SEEJ Index | Criteria weights Instruction | Weights | Results

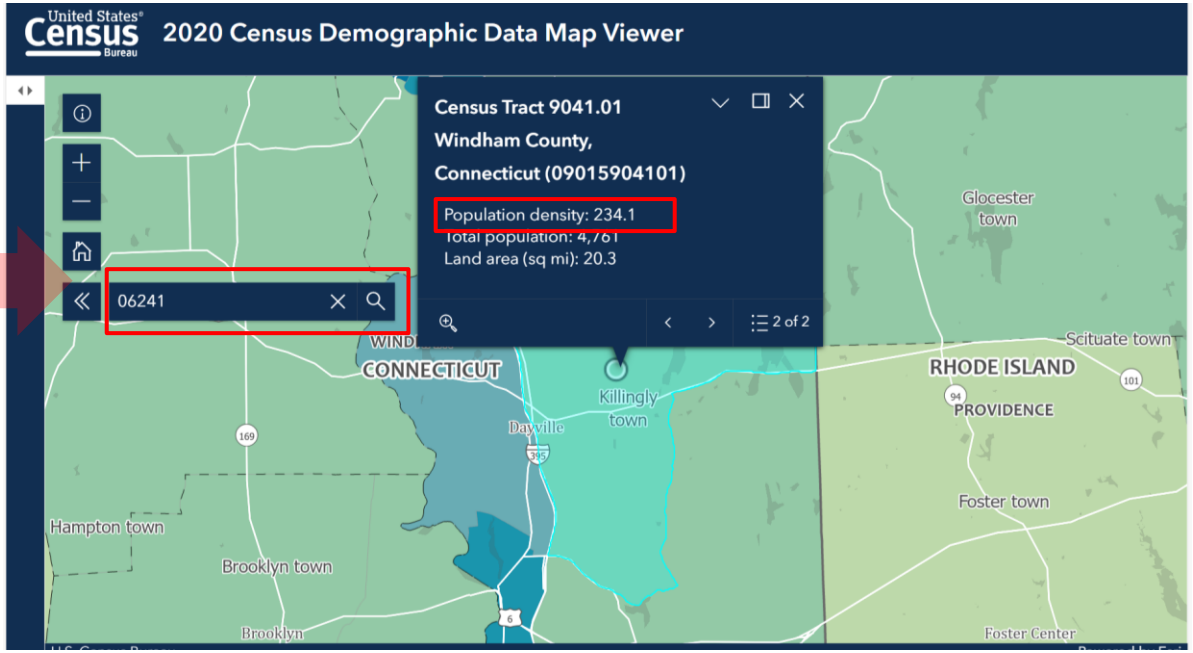
FIU-ABC Decision Support Tool: Population Density

- Navigate to the 2020 Census Demographic Data Map Viewer from the provided link in the “SEEJ Index Instruction” tab.

Data Link:

Population Density	https://maps.geo.census.gov/ddmv/map.html

- Use the "Find or Place" field to enter the address or coordinates (for this case study: zip code = 06241)



FIU-ABC Decision Support Tool: Population Density

- Copy and enter the population density value into the corresponding yellow cell (Table No. 1 of SEEJ Index tab).

Created by:	Nasim	Checked by:	
Date:	Tuesday, July 9, 2024	Date:	
Table No.	1	of	2

Social Equity Factor

Population Density Factor 1

Population Density — people per mi2 234.10

1 Less than 500
2 500 to 1000
3 1000 to 2000
4 2000 to 3000
5 More than 3000

Per Capita Income Factor

Per Capita Income $

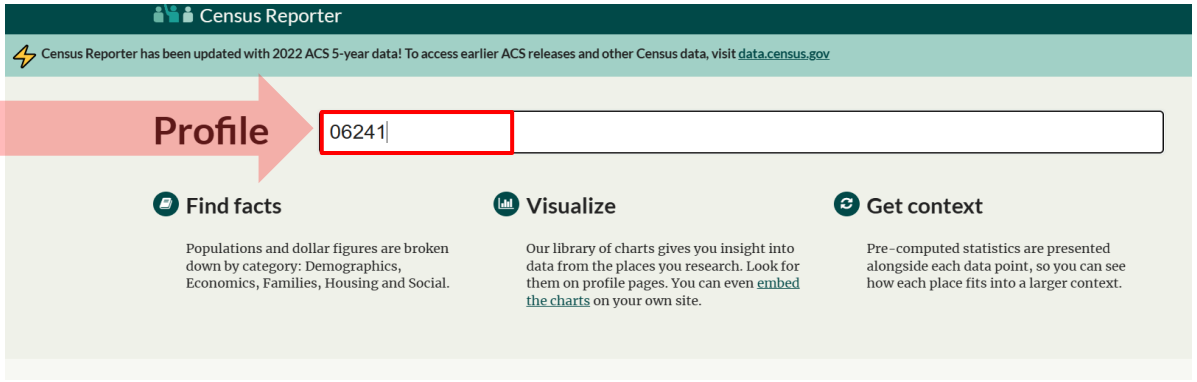
0 More than 70,000
1 60,000 to 70,000
2 50,000 to 60,000
3 40,000 to 50,000
4 30,000 to 40,000
5 Less than 30,000

FIU-ABC Decision Support Tool: Per Capita Income

- Navigate to the Census Reporter Data website from the provided link in the “SEEJ Index Instruction” tab.
- Use the “Profile" field to enter the address or coordinates (for this case study: zip code = 06241)
- Under the “Economics: Income” section, read and copy the per capita income value.

Data Link:

Per Capita Income — https://censusreporter.org/



FIU-ABC Decision Support Tool: Per Capita Income

- Copy and enter the PCI value into the corresponding yellow cell (Table No. 1 of SEEJ Index tab).

Created by:	Nasim	Checked by:	
Date:	Tuesday, July 9, 2024	Date:	
Table No.	1	of	2

Social Equity Factor 2.5

Population Density Factor 1

Population Density: people per mi2 234.10

1 Less than 500
2 500 to 1000
3 1000 to 2000
4 2000 to 3000
5 More than 3000

Per Capita Income Factor 4

Per Capita Income: $ 38,304.00

0 More than 70,000
1 60,000 to 70,000
2 50,000 to 60,000
3 40,000 to 50,000
4 30,000 to 40,000
5 Less than 30,000

FIU-ABC Decision Support Tool: Environmental Justice

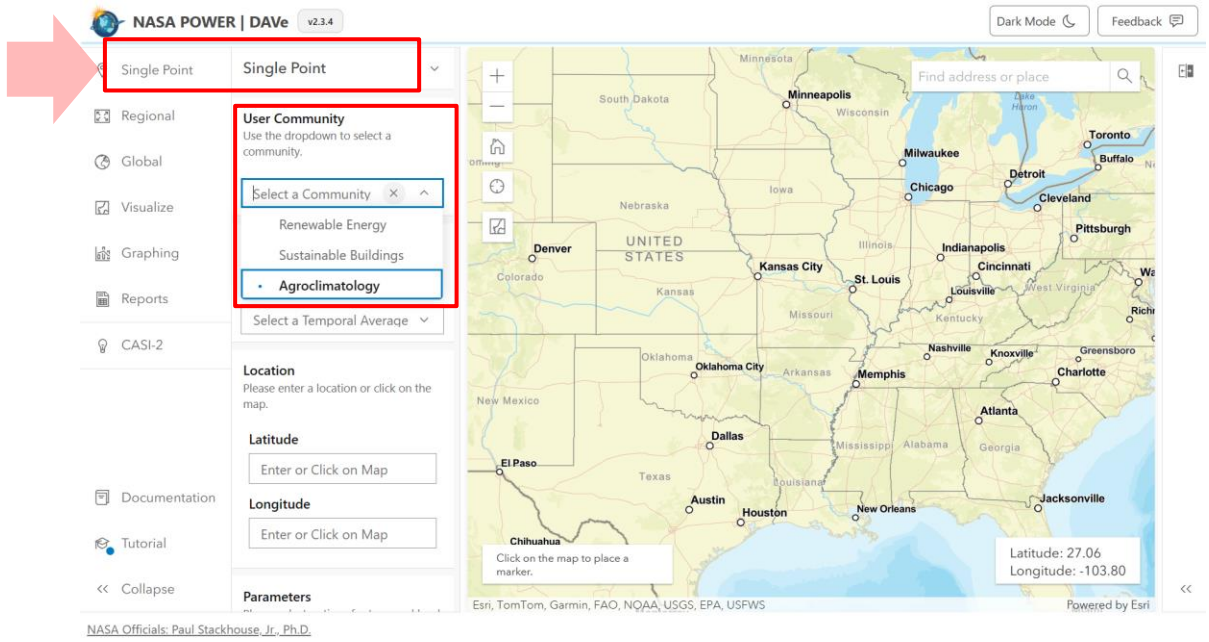
- Navigate to the NASA POWER Map Viewer from the provided link in the “SEEJ Index Instruction” tab.

- On the top left side, click the “Single Point”.

- Under “User Community” drop down section, click “Agroclimatology”.

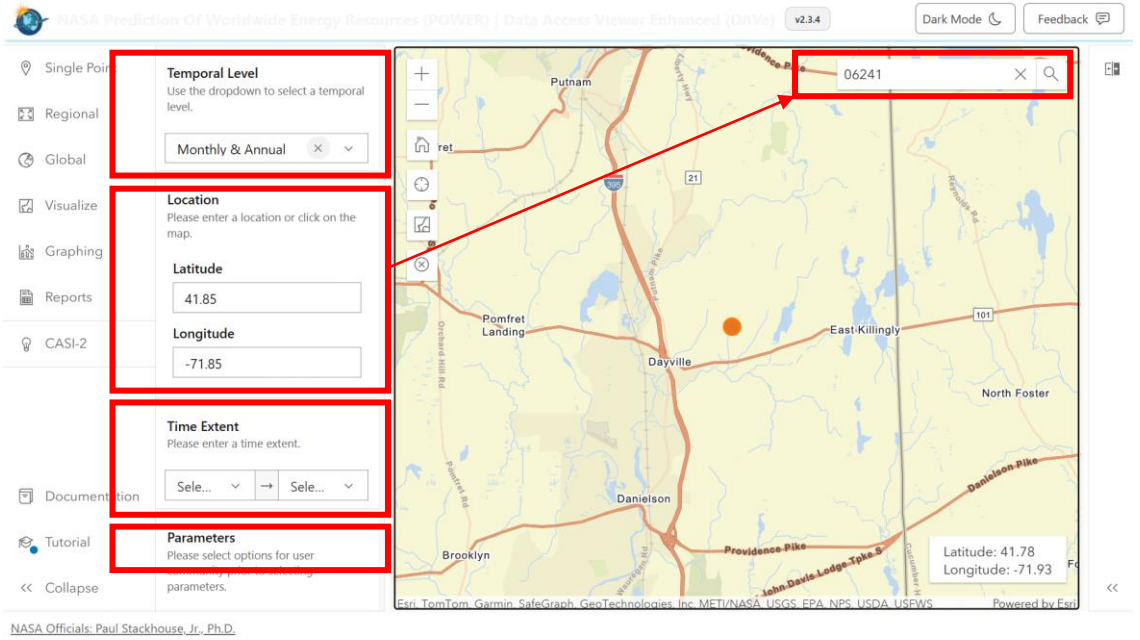
Data Link:

Temperature Relative Humidity Wind Speed	NASA Power Data Access Viewer



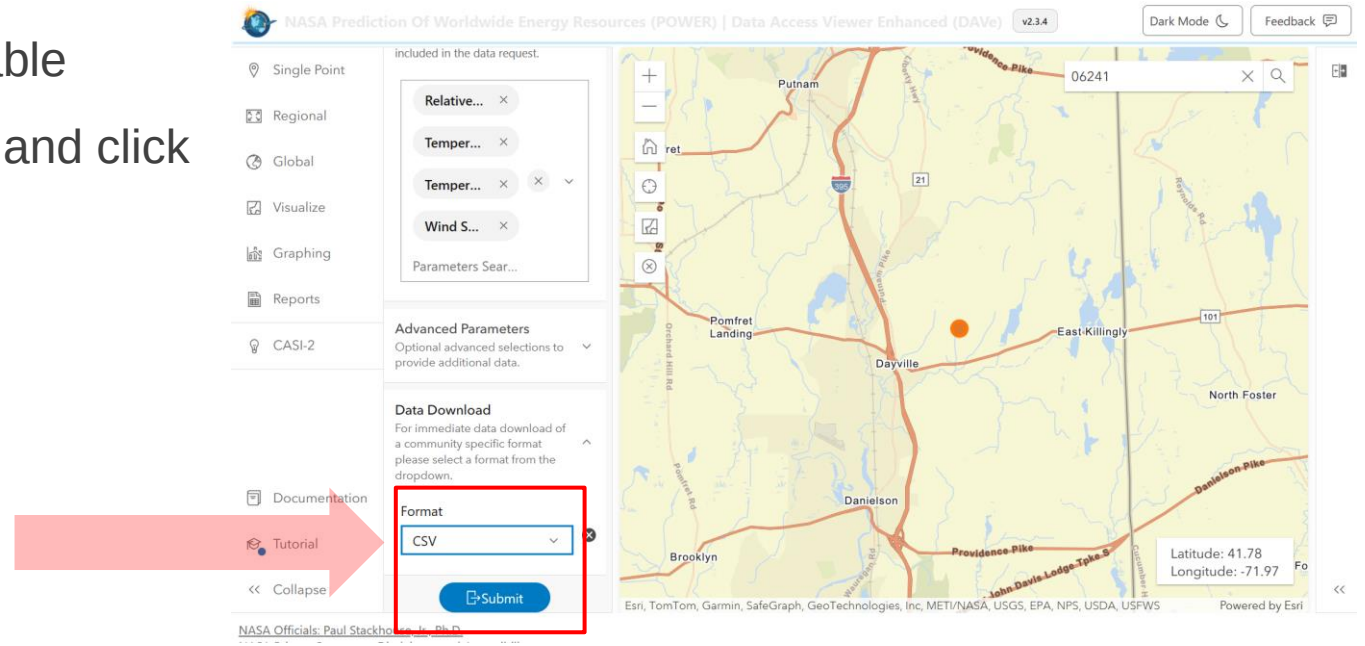
FIU-ABC Decision Support Tool: Temperature, Relative Humidity, Wind Speed

- For the “Temporal Level”, select the “Monthly and Annual”.
- For “ Location”, enter latitude and longitude coordinates in decimal degrees directly into the provided fields. Or using the "Find or Place" field to enter the address or coordinates (for this case study: zip code = 06241)
- For “Time Extent”, choose any five years. (here 2018 to 2022)
- Scroll down to the "Parameters“ and Choose variables.



FIU-ABC Decision Support Tool: Environmental Justice

- Choose CSV format from available formats for your data download and click “Submit”.



FIU-ABC Decision Support Tool: Temperature, Relative Humidity, Wind Speed

- Open the downloaded CSV file, extract the necessary data for each selected parameter, and input these into the respective cells in Excel Sheet for each year.

Parameter(s):														
RH2M	MERRA-2 Relative Humidity at 2 Meters (%)													
WS2M	MERRA-2 Wind Speed at 2 Meters (m/s)													
T2M_MAX	MERRA-2 Temperature at 2 Meters Maximum (C)													
T2M_MIN	MERRA-2 Temperature at 2 Meters Minimum (C)													
-END HEADER-														
PARAMETE	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
RH2M	2018	88.62	89.69	87.12	81.56	80.19	77.75	76.88	80.38	81.12	83.81	87.25	88.94	83.56
RH2M	2019	88	88.06	86.44	82.75	81.06	79.69	78.19	73.56	71.44	79.88	79.56	90	81.5
RH2M	2020	87.44	87.44	81.88	80.44	75.31	75.25	71.88	65.25	67.31	77.5	81.44	88	78.25
RH2M	2021	89	90.94	78.5	78.56	74.12	76.69	85.25	81.44	81.38	82.56	79.12	84.88	81.81
RH2M	2022	84.25	87.75	83.12	76.75	75.38	72.88	64.94	67.06	77.69	80.25	79.88	84.88	77.81
WS2M	2018	0.36	0.42	0.45	0.14	0.04	0.04	0.03	0.03	0.04	0.04	0.05	0.09	0.14
WS2M	2019	0.33	0.47	0.38	0.14	0.05	0.04	0.05	0.03	0.05	0.06	0.05	0.12	0.14
WS2M	2020	0.32	0.41	0.38	0.15	0.02	0.04	0.04	0.03	0.03	0.08	0.05	0.13	0.14
WS2M	2021	0.3	0.48	0.4	0.12	0.02	0.03	0.03	0.05	0.04	0.07	0.1	0.1	0.14
WS2M	2022	0.34	0.52	0.39	0.13	0.05	0.06	0.04	0.03	0.04	0.07	0.03	0.1	0.15
T2M_MAX	2018	14.18	18.96	14.94	19.99	29.06	30.48	38.58	34.26	34.38	26.46	19.06	15.37	38.58
T2M_MAX	2019	12.77	12.98	15.49	20.2	26.71	28.84	32.86	31.48	30.89	26.3	20.37	13.44	32.86
T2M_MAX	2020	16.2	11.02	16.89	18.15	26.69	30.43	35.15	34.97	32.14	24.68	23.01	17.08	35.15
T2M_MAX	2021	8.46	8	21.08	22.57	28.51	34.12	30.72	32.53	27.76	24.48	18.23	15.22	34.12
T2M_MAX	2022	8.99	17.07	20.13	19.75	29.41	32.53	36.23	37.09	31.01	23.63	22.23	13.48	37.09
T2M_MIN	2018	-26.13	-15.78	-13.04	-4.79	3.9	7.97	11.55	12.74	6.84	-3.79	-14.1	-11.35	-26.13
T2M_MIN	2019	-20.79	-17.92	-15.74	-4.57	2.53	5.7	13.58	9.96	4.83	1.58	-8.41	-14.68	-20.79
T2M_MIN	2020	-12.78	-17.2	-9.88	-4.36	-0.31	4.19	14.81	11.31	3.76	-8.51	-6.05	-15.07	-17.2
T2M_MIN	2021	-18.55	-18.18	-11.21	-4.92	2.7	8.4	10.42	12.6	7.94	1.03	-4.99	-8.05	-18.55
T2M_MIN	2022	-19.37	-18.05	-11.92	-2.71	1.01	8.31	13.2	14.16	6.18	-0.61	-5.28	-13.02	-19.37

FIU-ABC Decision Support Tool: Temperature, Relative Humidity, Wind Speed

- Copy and enter the data values in the corresponding cells.

Created by:	Nasim	Checked by:	
Date:	Tuesday, July 23, 2024	Date:	
Table No.	2	of	2

Environmental Justice Factor: 5

Feels Like Temperature Indicator: Heat Index: 59.5

Heat Index Categories	
1	Less than 27
2	27 to 32
3	32 to 41
4	41 to 55
5	More than 55

Wind Chill Index Categories	
1	More than 0
2	0 to -25
3	-25 to -35
4	-35 to -60
5	Less than -60

Annual Temperature- Max	°C	Year1	38.58
		Year2	32.86
		Year3	35.15
		Year4	34.12
		Year5	37.09
		Annual Average	35.56
Annual Temperature- Min	°C	Year1	-26.13
		Year2	-20.79
		Year3	-17.20
		Year4	-18.55
		Year5	-19.37
		Annual Average	-20.41
Annual Relatuve Humidity	%	Year1	83.56
		Year2	81.50
		Year3	78.25
		Year4	81.81
		Year5	77.81
		Annual Average	80.59
Annual Wind Speed	mps	Year1	0.14
		Year2	0.14
		Year3	0.14
		Year4	0.14
		Year5	0.15
		Annual Average	0.14

Weight Assignment

Instructions to Determine Relative Weights of Criteria:

To determine the relative importance (weights) of the given criteria in this decision support tool, there are two primary methods: 1) predetermined weights by decsion makers and 2) using the Analytical Hierarchy Process (AHP) method. Below is a guideline for each method.
Note: Users need to complete only one of the Tables: No. 1 or No. 2.

Guidelines:

Table No. 1: Predetermined Weights

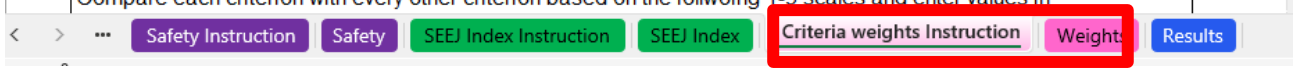
Assign a weight factor to each criterion based on expert judgment or organizational priorities. The following Table is just an example of predetermined weights. The weights for each case should be determined by relevant decsion makers.

Examples of predetermined weights

Criterion	Predetermined Weights Example
Average Daily Traffic	10
User Impact Reduction	30
Bridge Location	5
Use of Typical Details	5
Work Zone Geometery	8
Site Conditions	5
Railroad Impacts	5
Cost Analysis	30
Envir./Water Handeling	5
Waterway Limitations	5
Safety	30
SEEJ Index	20

Table No. 2: Using AHP for dedermining weights

Compare each criterion with every other criterion based on the follwoing 1-9 scales and enter values in



FIU-ABC Decision Support Tool: Relative Importance (Weights) of Criteria

- Use Table No. 1 for applying weights that are already established based on prior standards, expert judgment, or organizational priorities.

- Use Table No. 2 for a more detailed and subjective method that involves pairwise comparisons.

Table No.1

Predetermined Weights

Criterion	Predetermine	Predetermined Weights Example
Average Daily Traffic	10	10
User Impact Reduction	30	30
Bridge Location	5	5
Use of Typical Details	5	5
Work Zone Geometery	8	8
Site Conditions	5	5
Railroad Impacts	5	5
Cost Analysis	30	30
Envir./Water Handeling	5	5
Waterway Limitations	5	5
Safety	30	30
SEEJ Index	20	20

Table No. 2

Analytical Hierarchy Process (AHP) Weights

Criterion	Average Daily Traffic	User Impact Reduction	Bridge Location	Use of Typical Details	Work Zone Geometery	Site Conditions	Railroad Impacts	Cost Analysis	Envir./Water Handeling	Waterway Limitations	Safety	SEEJ Index	Weight
Average Daily Traffic	1	3	3	5	5	7	7	5	7	9	7	9	0.26
User Impact Reduction	0.33	1	3	3	5	5	5	3	5	7	5	7	0.17
Bridge Location	0.33	0.33	1	3	3	5	5	3	5	7	5	7	0.14
Use of Typical Details	0.20	0.33	0.33	1	3	3	3	3	5	5	3	5	0.09
Work Zone Geometery	0.20	0.20	0.33	0.33	1	3	3	3	3	5	3	5	0.07
Site Conditions	0.14	0.20	0.20	0.33	0.33	1	3	3	3	5	3	5	0.06
Railroad Impacts	0.14	0.20	0.20	0.33	0.33	0.33	1	3	3	5	3	5	0.05
Cost Analysis	0.20	0.33	0.33	0.33	0.33	0.33	0.33	1	3	5	3	5	0.05
Envir./Water Handeling	0.14	0.20	0.20	0.20	0.33	0.33	0.33	0.33	1	3	3	5	0.03
Waterway Limitations	0.11	0.14	0.14	0.20	0.20	0.20	0.20	0.20	0.33	1	3	5	0.03
Safety	0.14	0.20	0.20	0.33	0.33	0.33	0.33	0.33	0.33	0.33	1	3	0.02
SEEJ Index	0.11	0.14	0.14	0.20	0.14	0.20	0.20	0.20	0.20	0.20	0.33	1	0.01

Comparison of ABC Scores in CTDOT and FIU Tools

1) CTDOT Decision Matrix:

- No Safety
- No SEEJ

	Score	Predetermind Weights	Weighted Score	Maximum Possible Score	Maximum Possible Weighted Score
Average Daily Traffic	2.0	10	20	5	50
User Impact Reduction	1.0	30	30	5	150
Bridge Location	1.0	5	5	5	25
Use of Typical Details	4.0	5	20	5	25
Work Zone Geometry	3.0	8	24	5	40
Site Conditions	3.0	5	15	5	25
Railroad Impacts	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Cost Analysis	3.0	30	90	5	150
Envir. /Water Handling	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Waterway Limitations	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Safety Benefits	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
SEEJ Index	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
		Total Score	204	Max. Score	465

ABC Rating	**44**

ABC Rating Scale	
60-100	Use ABC
50-60	Consider ABC
0-50	Do not use ABC

2) FIU ABC Tool:

- Added Safety Benefit

	Score	Predetermind Weights	Weighted Score	Maximum Possible Score	Maximum Possible Weighted Score
Average Daily Traffic	2.0	10	20	5	50
User Impact Reduction	1.0	30	30	5	150
Bridge Location	1.0	5	5	5	25
Use of Typical Details	4.0	5	20	5	25
Work Zone Geometry	3.0	8	24	5	40
Site Conditions	3.0	5	15	5	25
Railroad Impacts	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Cost Analysis	3.0	30	90	5	150
Envir. /Water Handling	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Waterway Limitations	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Safety Benefits	5.0	30	150	5	150
SEEJ Index	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
		Total Score	354	Max. Score	615

ABC Rating	**58**

ABC Rating Scale	
60-100	Use ABC
50-60	Consider ABC
0-50	Do not use ABC

3) FIU ABC Tool

- Added Safety Benefit
- Added SEEJ

	Score	Predetermind Weights	Weighted Score	Maximum Possible Score	Maximum Possible Weighted Score
Average Daily Traffic	2.0	10	20	5	50
User Impact Reduction	1.0	30	30	5	150
Bridge Location	1.0	5	5	5	25
Use of Typical Details	4.0	5	20	5	25
Work Zone Geometry	3.0	8	24	5	40
Site Conditions	3.0	5	15	5	25
Railroad Impacts	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Cost Analysis	3.0	30	90	5	150
Envir. /Water Handling	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Waterway Limitations	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Safety Benefits	5.0	30	150	5	150
SEEJ Index	3.7	20	74	5	100
		Total Score	428	Max. Score	715

ABC Rating	**60**

ABC Rating Scale	
60-100	Use ABC
50-60	Consider ABC
0-50	Do not use ABC

Conclusion

- First time incorporation of quantified ABC benefits for improving work zone **safety** in ABC decision making.
- First time incorporation of **social equity** and **environmental justice** in ABC decision making.
- Incorporation of a systematic method for weight assignments to decision criteria.
- FIU-ABC tool uses nationally available data ➔ Applicable to all State DOTs.
  - Simple (Excel based)
  - Adjustable (User can change weights)
  - Capable of group decision making

Areas for Future Work

- Provide more examples from different states.
- Improve the tool to include less qualitative evaluations.
- Incorporate ABC benefits for reducing greenhouse gas emissions into the tool.
- Convert the tool to an online automatic tool.

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ABC UTC IBT

INNOVATIVE BRIDGE TECHNOLOGIES/ACCELERATED BRIDGE CONSTRUCTION
UNIVERSITY TRANSPORTATION CENTER

FIU Engineering & Computing

Thank you!

Questions and Comments?

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