



Optimization Model for Highway Work Zones (HWZs) Considering Safety, Mobility, and Work costs

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Outline

- Background & Motivation
- Research Objective
- Optimization Model
- Conclusions



Background & Motivation



- Significant adverse impacts
 - 19B dollar per year
 - 10% of overall congestion delay
 - Increased crash risk: 40,000 injuries, 800 fatalities



HWZ cost components

Work

Agency

Material, equipment, labor, site overheads

TTC

Temporary traffic control

Mobility

Lost time

Extra traveled time

VOC

Vehicle operation costs

Emissions

Change in emission cost

Safety

Crash

Change in crash cost



Background & Motivation

- A tool is needed to plan HWZ operations
 - Mitigate its adverse impacts
 - Optimization to minimize total cost
 - Consider all cost components



HWZ optimization models

- Current models (e.g., Chen and Schonfeld, 2004 ; Yang et al., 2009; Du and Chien, 2014)
 - Simplified agency costs and schedule
 - Crash costs and VOC as fraction of lost time
 - Traffic diversion model is missing
 - None considered emission cost



This research

- Develop HWZ optimization model
 - Consider safety, mobility, and work costs
- Incorporate
 - Location-based schedule
 - Crash cost model
 - Traffic flow model with alternative route choice



Objective function

$$\text{Min}(TPC) = \text{Min}(AGC + TCC + LTS + VOC + EMC + CRC)$$

s.t.

$$LB_i \leq X_i \leq UB_i \quad i = 1, 2, \dots, n$$

$$AGC + TCC \leq B^{max}$$

$$D \leq D^{max}$$

$$TCMF \leq TCMF^{max}$$

$$LT \leq LT^{max}$$

$$G(X) \leq 0$$

TPC - Total project cost

AGC - Agency cost

TCC - Temporary traffic control cost

LTC - Lost time cost

VOC - Vehicle operating cost

EMC - Emission cost

CRC - Crash cost

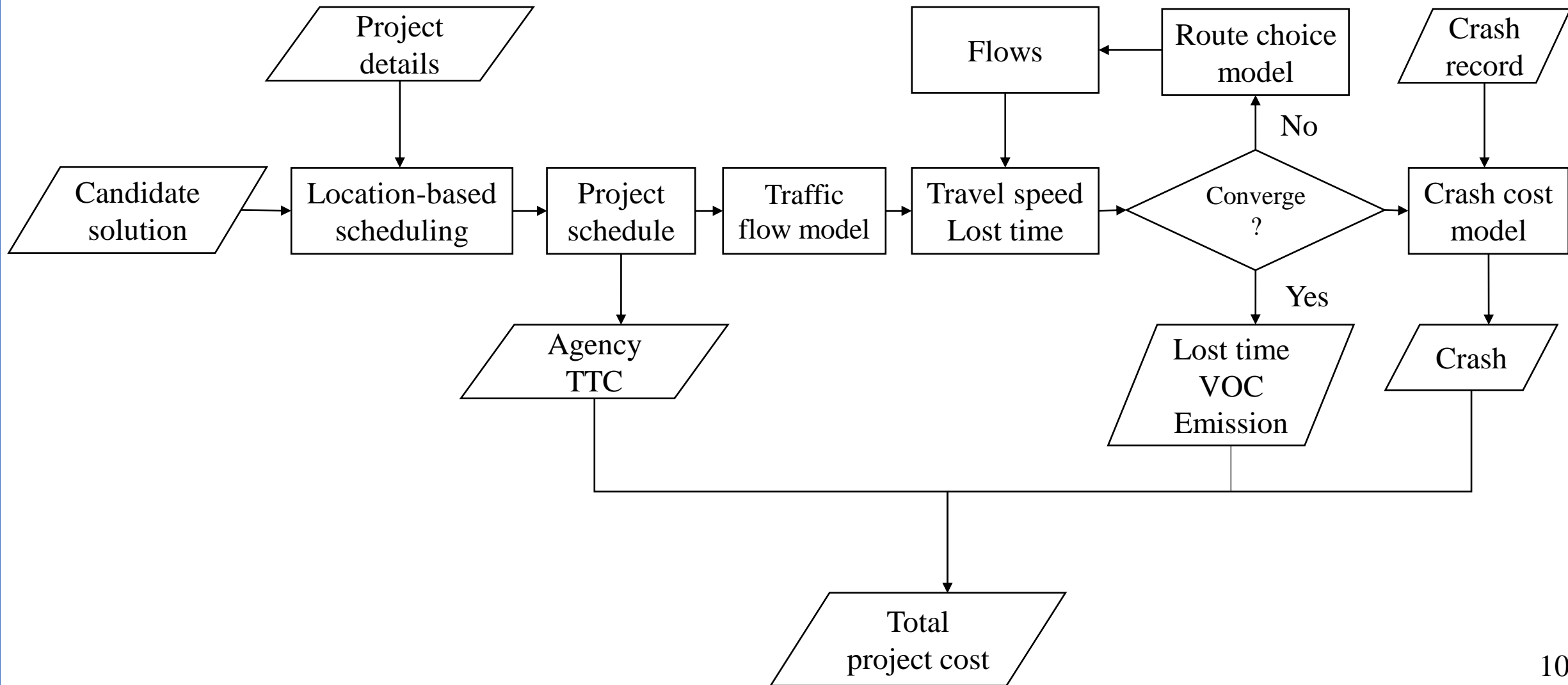


Decision variables

- Work schedule
 - Work days, hours, and start time/Crew formation
- TTC (Temporary Traffic Control)
 - Variable message signs/Speed display/Attenuator/Photo enforcement/flagger and police presence/Posted speed limit
- Site geometry
 - Workspace length/Lateral clearance, lane and shoulder width

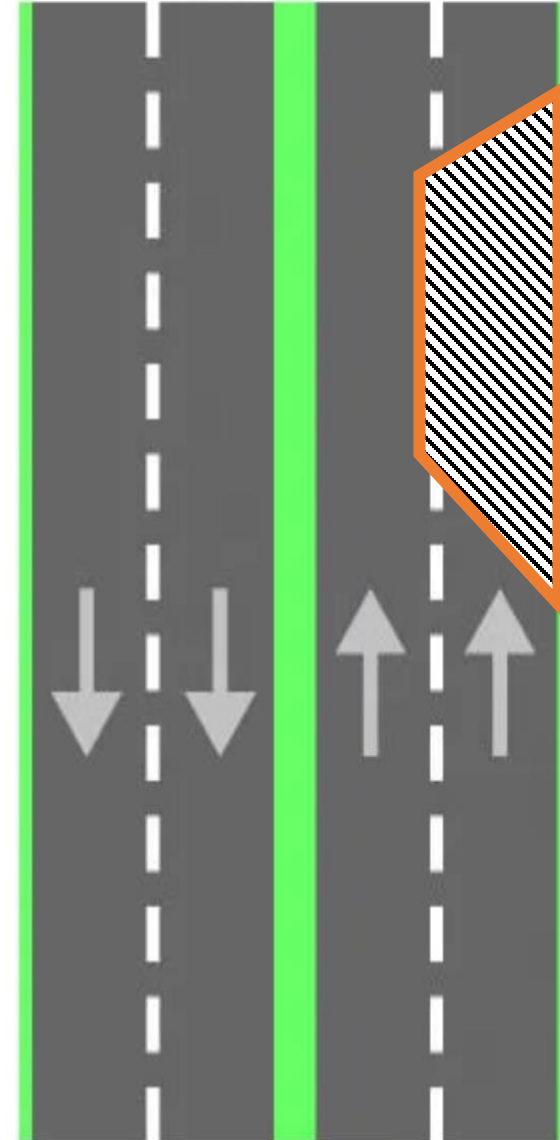


Objective function calculation



Case study

- 20 km resurfacing project
- Scenarios:
 - Unrestricted time of day vs daytime only
 - Use of optional TTC
 - Proposed vs simplified models





Proposed model

	Unrestricted time of day		Daytime only	
Optional TTC	Available	Not Available	Available	Not Available
Scenario	1	2	3	4
Costs				
Total project cost (\$)	668,690	709,540	1,825,400	1,928,300
Agency	91.92%	89.06%	34.60%	32.76%
TTC	7.62%	6.42%	2.72%	2.05%
Lost time	3.59%	0.59%	64.14%	61.40%
Vehicle operation	0.67%	0.29%	1.32%	1.35%
Emission	-0.03%	-0.03%	0.07%	0.06%
Crash	-3.76%	3.67%	-2.86%	2.38%
Project impacts				
Total delay (veh-hr)	1,094	192	53,400	53,997
TCMF	0.27	2.04	0.24	1.65
Workspace length (m/day)	1,418	1,103	1,103	1,103
Project duration (days)	14	18	18	18
Work start time	10 PM	11 PM	5 AM	5 AM



Models' comparison

	Unrestricted time of day Optional TTC available		
Model	Proposed	Simplified agency and schedule	Simplified crash cost
Costs			
Total project cost (\$)	668,690	766,560	681,440
Agency	91.92%	93.93%	91.31%
TTC	7.62%	7.66%	6.50%
Lost time	3.59%	0.58%	1.78%
Vehicle operation	0.67%	0.30%	0.43%
Emission	-0.03%	-0.03%	0.03%
Crash	-3.76%	-2.44%	0.01%
Project impacts			
Total delay (veh-hr)	1,094	204	555
TCMF	0.27	0.27	-
Workspace length (m/day)	1,418	1,000	1,260
Project duration (days)	14	20	16
Work start time	10 PM	11 PM	10 PM



Conclusions

- Developed HWZ optimization model
 - Account for all cost components
 - Incorporate location-based scheduling, crash cost model, and alternative route choice
- Case study
 - Crash costs are substantial, optional TTC are recommended
 - Location-based scheduling improves the cost estimates
 - Emission costs are relatively small



Thanks For Your Attention Any Questions ?

