



LCAP

Lane Closure Analysis Program



MDOT State Highway Administration
Office of Traffic & Safety
Traffic Development & Support Division



University of Maryland, College Park
Dept. of Civil & Environmental Engineering
Traffic Safety & Operations Lab

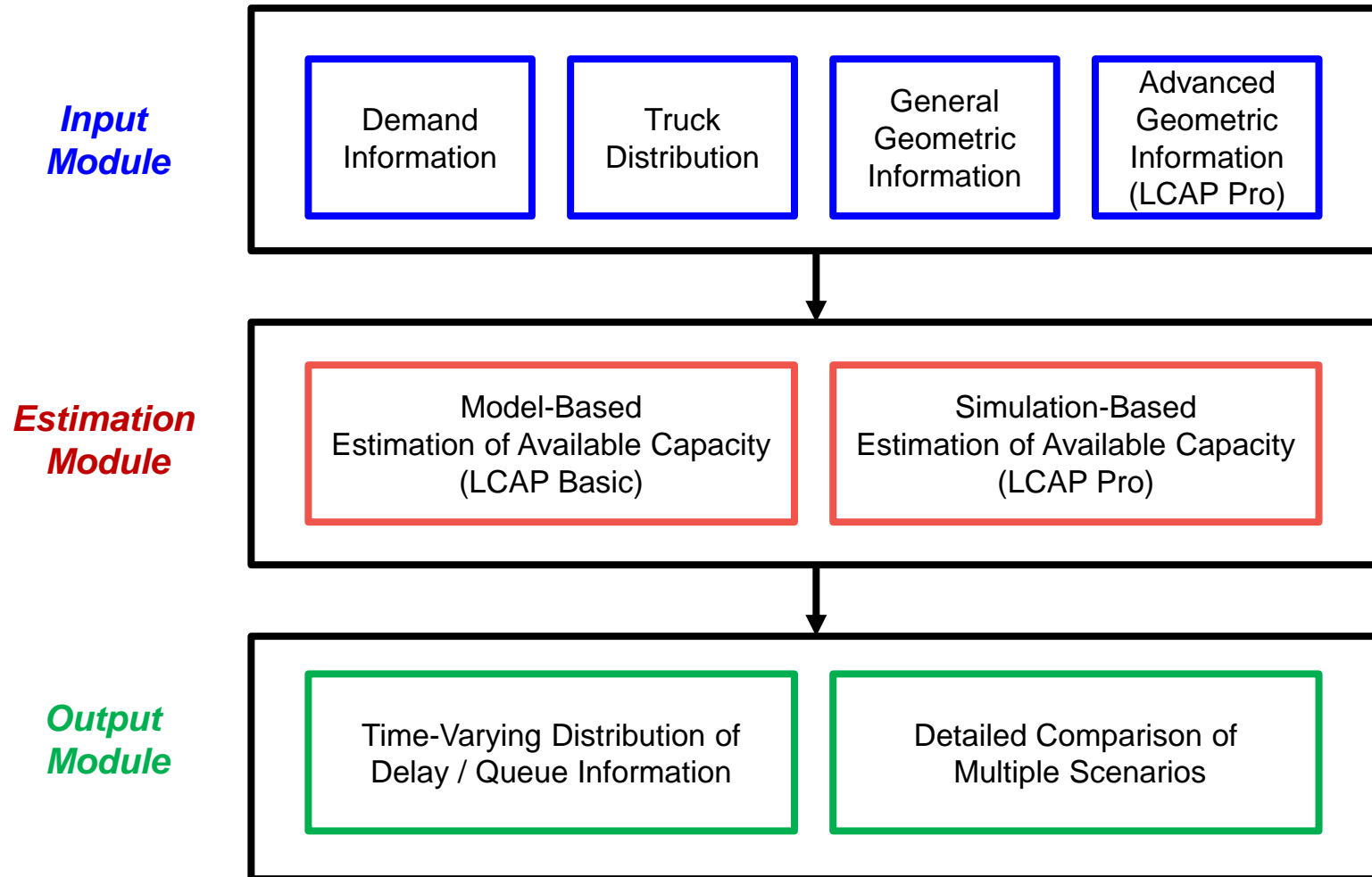
LCAP: Lane Closure Analysis Program

- ✿ LCAP is a tool designed to determine the available traffic capacity under freeway work-zone operations and to estimate the resulting queues from candidate work-zone schedules.
- ✿ Developed by University of Maryland and MDOT SHA

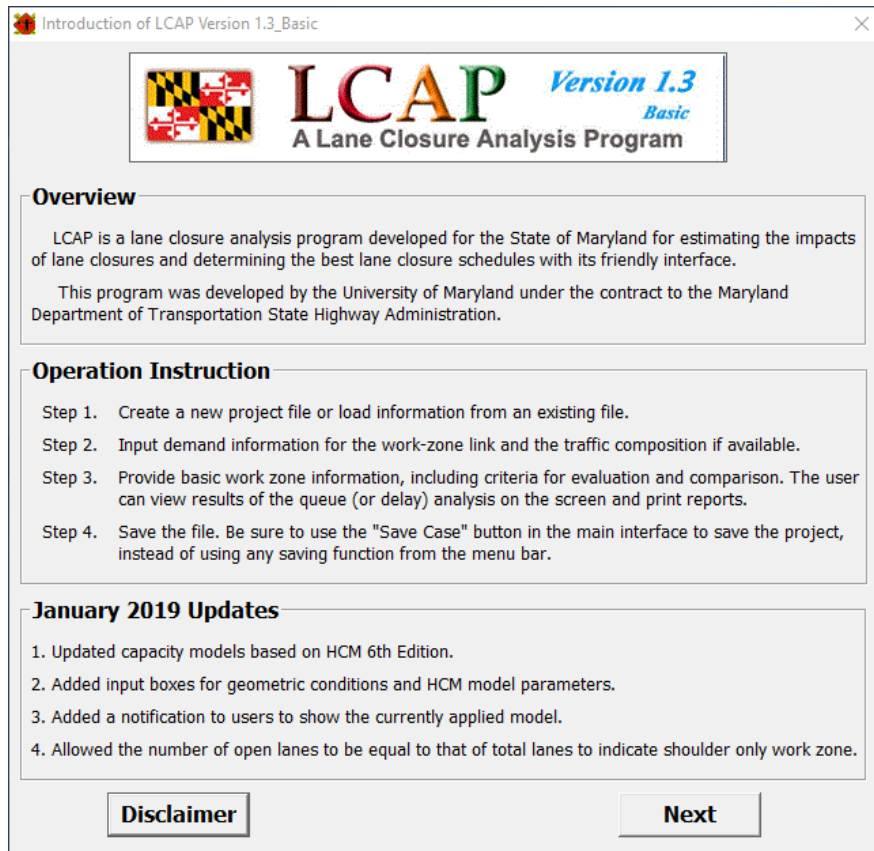
LCAP: Basic and Pro

- ✿ Two versions are available:
 - **LCAP-Basic**: provides users a tool for quick estimation of the queue/delay caused by freeway work-zone operations using a capacity estimation model from HCM 6th Edition.
 - **LCAP-Pro**: integrates a microscopic simulation module (i.e., TSIS-CORSIM), which can estimate the impact of the work-zone with consideration of various factors, including complex geometry features, drivers interaction to work-zone warning signs, and traffic conditions.

System Framework



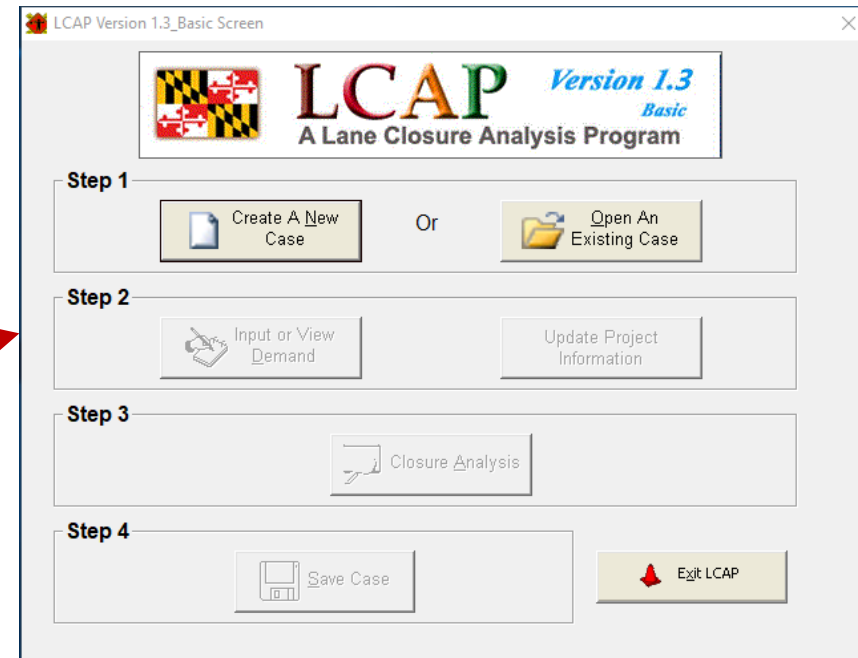
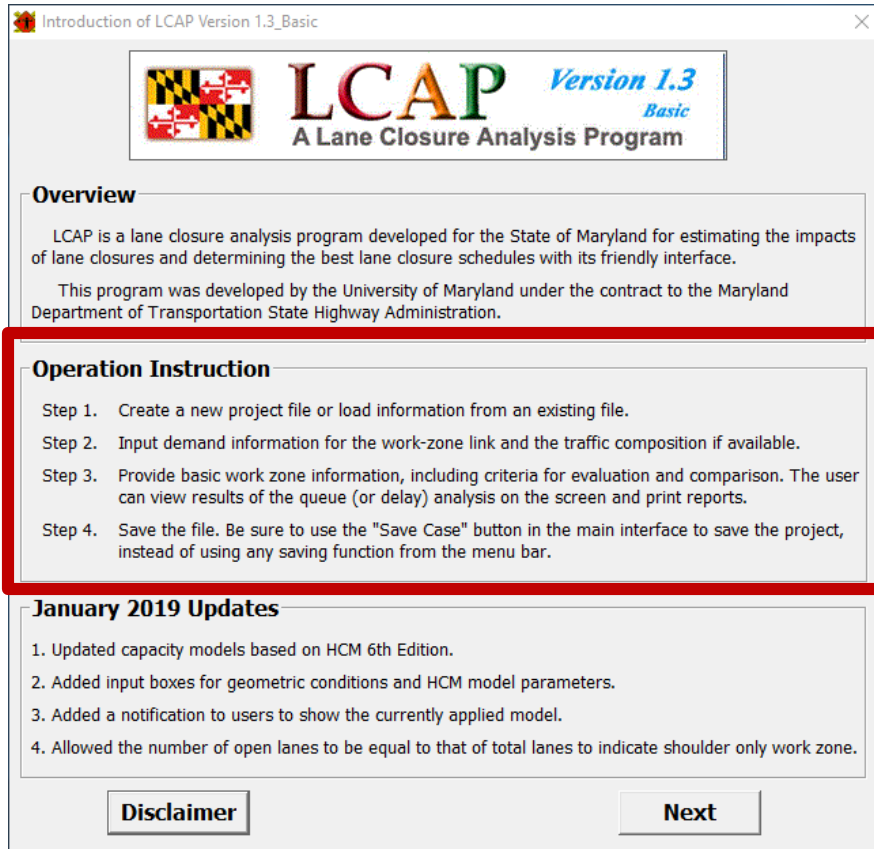
LCAP – Basic v 1.3



✿ Users can quickly obtain **an estimate of the available capacity** for **a typical freeway work-zone configuration** and evaluate **the resulting traffic queues**.

✿ Estimate the available capacity of work zones for general scenarios using a model from **Highway Capacity Manual 6th Edition** for short-term work zone.

LCAP – Basic v 1.3



Input Module (LCAP – Basic v 1.3)

Demand Input

Volume Type
☒ Vehicles
☐ PCE

PCE Value

PCE Value for Trucks:

Return to Main

Truck Percentage

AM	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
Weekday	0.05	0.01	0.08	0.13	0.8	0.1	0.32	0.05	0.01	0.12	0.15	0.2
Weekend	0.05	0.01	0.08	0.13	0.8	0.1	0.32	0.05	0.01	0.12	0.15	0.2
PM	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Weekday	0.05	0.62	0.12	0.12	0.02	0.2	0.61	0.23	0.22	0.22	0.22	0.22
Weekend	0.05	0.62	0.12	0.12	0.02	0.2	0.61	0.23	0.22	0.22	0.22	0.22

Demand Input

AM	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
Sunday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Monday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Tuesday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Wednesday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Thursday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Friday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Saturday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
PM	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Sunday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Monday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Tuesday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Wednesday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Thursday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Friday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Saturday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000

- Hourly volume
- Truck percentage
- PCE value

Estimation Module (LCAP – Basic v 1.3)

Work-Zone Information

Please click the Work-Zone Capacity Reference button after every change of inputs.

Save Change Return to Main

Output Type

☒ Queue
☐ Delay

Lane Closure Information

Number of lanes: 4 Number of open lane(s): 1

Geometric Conditions

Barrier type: concrete and hard barrier separation
Area type: rural areas Light condition: daylight
Lateral distance: 0 ft Terrain: level terrain

Capacity Information

Capacity per lane: 1800 vphpl Work-zone capacity per lane: 1356 vphpl
Total capacity w/o WZ: 7200 vph Total capacity reduction due to WZ: 5844 vph
Total work-zone capacity: 1356vph
Applied model: N/A

Work-Zone Capacity Reference

Choose the Work Zone time (optional)

Start of Work-Zone End of Work-Zone

Display Option

☒ Base Demand ☒ Approach Volume ☒ Roadway Volume ☒ Vehicles in Queue ☒ Work Zone Up

Comparison Option

☒ No Comparison ☐ Compare with 10% More Volume ☐ Compare with 10% Less Volume

Show Analysis Results

- ✱ Output type
- ✱ Lane closure condition
- ✱ Geometric condition
- ✱ Estimated capacity
- ✱ Options (input/output display, comparison)

Estimation Module (LCAP – Basic v 1.3)

Work-Zone Information

Please click the Work-Zone Capacity Reference button after every change of inputs.

Output Type

☒ Queue
☐ Delay

Lane Closure Information

Number of lanes: Number of open lane(s):

Geometric Conditions

Barrier type:
Area type: Light condition:
Lateral distance: ft Terrain:

Capacity Information

Capacity per lane: vphpl Work-zone capacity per lane: vphpl
Total capacity w/o WZ: **7200 vph** Total capacity reduction due to WZ: vph
Total work-zone capacity: **1356vph**
Applied model: **N/A**

Work-Zone Capacity Reference

Choose the Work Zone time (optional)

Start of Work-Zone End of Work-Zone

Display Option

☒ Base Demand ☒ Approach Volume ☒ Roadway Volume ☒ Vehicles in Queue ☒ Work Zone Up

Comparison Option

☒ No Comparison ☐ Compare with 10% More Volume ☐ Compare with 10% Less Volume

Work-zone Capacity

Please select the below model for determining the work zone capacity. More models are to be integrated in LCAP.

☒ Model 1: HCM 6th Edition Work Zone Model (2016)

Percentage drop in pre-breakdown capacity at the work zone due to queueing condition(%)
Lane Closure Severity Index(LCSI): Heavy vehicle Percentage: %
Peak Hour Factor: Capacity: **1356** vphpl

Reference Model for Available Capacity: from **the Highway Capacity Manual 6th Edition** for short-term work zones

Estimation Module (LCAP – Basic v 1.3)

Work-Zone Information

Please click the Work-Zone Capacity Reference button after every change of inputs.

Output Type

☒ Queue
☐ Delay

Lane Closure Information


Number of lanes: Number of open lane(s):

Geometric Conditions

Barrier type:
Area type: Light condition:
Lateral distance: ft Terrain:

Capacity Information

Capacity per lane: vphpl Work-zone capacity per lane: vphpl
Total capacity w/o WZ: **7200 vph** Total capacity reduction due to WZ: vph
Total work-zone capacity: **1356vph**
Applied model: **N/A**

 **Work-Zone Capacity Reference**

Choose the Work Zone time (optional)

Start of Work-Zone: End of Work-Zone:

Display Option

☒ Base Demand ☒ Approach Volume ☒ Roadway Volume ☒ Vehicles in Queue ☒ Work Zone Up

Comparison Option

☒ No Comparison ☐ Compare with 10% More Volume ☐ Compare with 10% Less Volume

Show Analysis Results

Work-zone Capacity

Please select the below model for determining the work zone capacity. More models are to be integrated in LCAP.

☒ **Model 1: HCM 6th Edition Work Zone Model (2016)**

Percentage drop in pre-breakdown capacity at the work zone due to queueing condition(%)
Lane Closure Severity Index(LCSI): Heavy vehicle Percentage: %
Peak Hour Factor: Capacity: **1356** vphpl

Reference **Cancel** **Apply**

Reference for Workzone Capacity Estimation

Model 1

Previous Page 1 of 3 Next Close

Work Zone Capacity (prebreakdown flow rate)

$$c_{wz} = \frac{QDR_{wz}}{100 - \alpha_{wz}} \times 100$$

with $QDR_{wz} = 2.093 - 154 \times LCSI - 194 \times f_{BT} - 179 \times f_{AT} + 9 \times f_{LAT} - 59 \times f_{DN}$

Where

QDR_{wz} = average 15-min queue discharge rate (pc/h/ln) at the work zone bottleneck
 α_{wz} = percentage drop in prebreakdown capacity at the work zone due to queueing conditions (%).
 The average value of this in work zones is 13.4%
 f_{AT} = indicator factor for area type:
 = 0 for urban areas (i.e., typified by high development densities or concentrations of population), and
 = 1 for rural areas (i.e., areas with widely scattered development and low housing and employment densities);
 f_{LAT} = lateral distance from the edge of travel lane adjacent to the work zone to the barrier, barricades, or cones (0–12 ft);

$$LCSI = \frac{1}{OR \times N_o}$$

where
 $LCSI$ = lane closure severity index (decimal);
 OR = open ratio, the ratio of the number of open lanes during road work to the total (or normal) number of lanes (decimal); and
 N_o = number of open lanes in the work zone (ln).

Output Module (LCAP – Basic v 1.3)

Analysis Report

	Start Time	End Time	Base Demand	Approach Volume	Roadway Volume	Vehicle in Queue	Queue Length (Miles)	WZ Up
1	Sun-23:00	Mon-0:00	3000	3000	3000	0	0	
2	Mon-0:00	Mon-1:00	1000	1000	1000	0	0	
3	Mon-1:00	Mon-2:00	1000	1000	1000	0	0	
4	Mon-2:00	Mon-3:00	1000	1000	1000	0	0	
5	Mon-3:00	Mon-4:00	1000	1000	1000	0	0	
6	Mon-4:00	Mon-5:00	1000	1000	1000	0	0	
7	Mon-5:00	Mon-6:00	1000	1000	1000	0	0	
8	Mon-6:00	Mon-7:00	1000	1000	1000	0	0	
9	Mon-7:00	Mon-8:00	4000	4000	4000	0	0	
10	Mon-8:00	Mon-9:00	4000	4000	4000	0	0	
11	Mon-9:00	Mon-10:00	5100	1356	5100	3744	4.92	X
12	Mon-10:00	Mon-11:00	5100	1356	8844	7488	9.85	X
13	Mon-11:00	Mon-12:00	5100	1356	12588	11232	14.77	X
14	Mon-12:00	Mon-13:00	7000	7200	18232	11032	14.51	
15	Mon-13:00	Mon-14:00	7000	7200	18032	10832	14.25	
16	Mon-14:00	Mon-15:00	7000	7200	17832	10632	13.98	
17	Mon-15:00	Mon-16:00	5000	7200	15632	8432	11.09	
18	Mon-16:00	Mon-17:00	5000	7200	13432	6232	8.2	
19	Mon-17:00	Mon-18:00	5000	7200	11232	4032	5.3	
20	Mon-18:00	Mon-19:00	5000	7200	9032	1832	2.41	
21	Mon-19:00	Mon-20:00	5000	6832	6832	0	0	
22	Mon-20:00	Mon-21:00	3000	3000	3000	0	0	
23	Mon-21:00	Mon-22:00	3000	3000	3000	0	0	

Save Results to CSV File

Return to Main

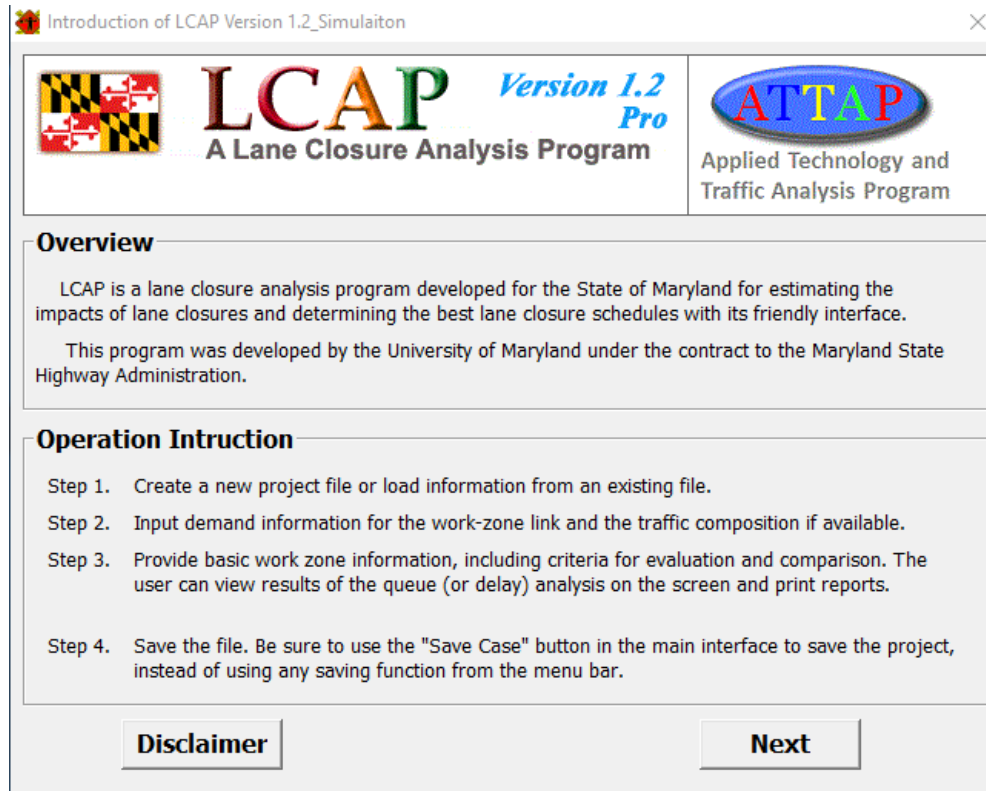
✿ **Input:** time, base demand, approach volume and roadway volume

✿ **Output:** vehicles in queue, queue length (miles) or delay (min), WZ up

✿ **WZ up**

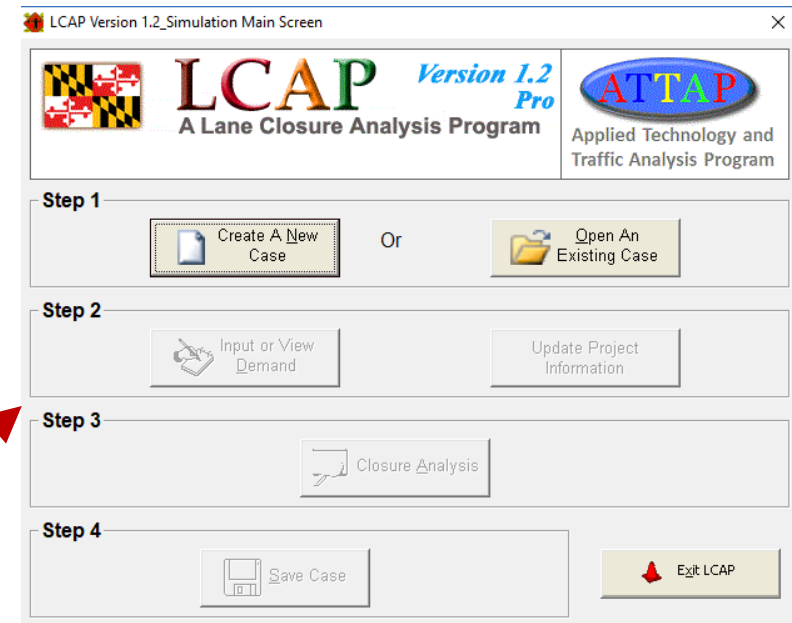
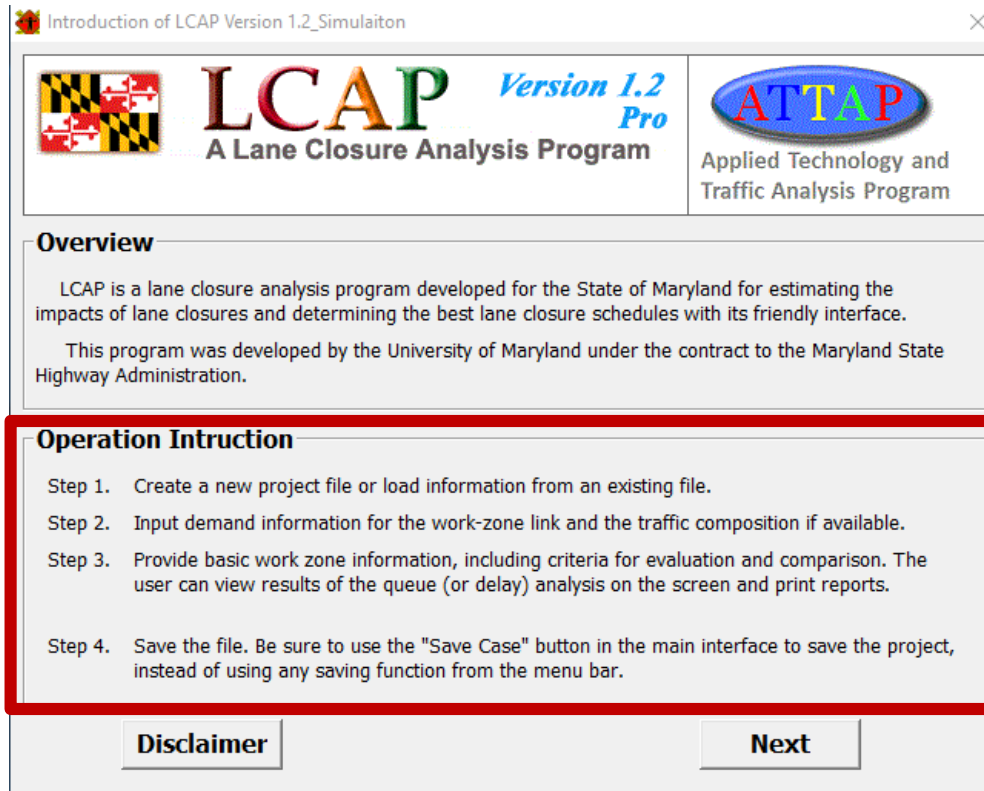
- “X” indicates that work zone is set up and in operations.
- Help users to understand the impacts of work zone on traffic condition (i.e., queue formation)

LCAP – Pro v 1.2



- ✿ Precisely estimate the available capacity of freeway work-zone operations on a complex roadway segment, including ramp impacts.
- ✿ Embedded ability to execute CORSIM.
- ✿ Perform detailed simulations of work-zone traffic conditions and compute the MOEs at a microscopic level.

LCAP – Pro v 1.2



Input Module (LCAP – Pro v 1.2)

Demand Input

Volume Type
☒ Vehicles
☐ PCE

PCE Value

PCE Value for Trucks:

Return to Main

Truck Percentage

AM	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
Weekday	0.05	0.01	0.08	0.13	0.8	0.1	0.32	0.05	0.01	0.12	0.15	0.2
Weekend	0.05	0.01	0.08	0.13	0.8	0.1	0.32	0.05	0.01	0.12	0.15	0.2
PM	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Weekday	0.05	0.62	0.12	0.12	0.02	0.2	0.61	0.23	0.22	0.22	0.22	0.22
Weekend	0.05	0.62	0.12	0.12	0.02	0.2	0.61	0.23	0.22	0.22	0.22	0.22

Demand Input

AM	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00
Sunday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Monday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Tuesday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Wednesday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Thursday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Friday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
Saturday	1000	1000	1000	1000	1000	1000	1000	4000	4000	5100	5100	5100
PM	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Sunday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Monday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Tuesday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Wednesday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Thursday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Friday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000
Saturday	7000	7000	7000	5000	5000	5000	5000	5000	3000	3000	3000	3000

- Hourly volume
- Truck percentage
- PCE value

Estimation Module (LCAP – Pro v 1.2)

Work-Zone Information

Please input work-zone information, then click the button to show analysis result.

Save Change Return to Main

Lane Closure Information

Number of lanes: 4 Number of open lane(s): 2 Lanes closed at: Right

Choose the Work Zone time

Start of Work-Zone Monday 9:00 Simulation Hours before start of Work_Zone: 2
End of Work-Zone Monday 12:00 Simulation Hours after end of Work_Zone: 7

Geometry Information (NDT in Scale)

On Ramp Off Ramp Ramp Info. Work_Zone Speed Limit 45 mph Traffic Direction Normal Speed Limit 65 mph

Speed Limit 77 500 300 On Ramp Off Ramp Ramp Info. lane4 lane3 lane2 lane1

On Ramp Off Ramp 1500 100 Length of WZ 300 End of WZ 150 On Ramp Off Ramp Ramp Info. 500 300

Unit: feet

Output Type

Queue Show in red if QUEUE > 3.0 Miles
Delay Otherwise, show in yellow if QUEUE > 1.0 Miles

Display Option

Base Demand Approach Volume Roadway Volume Vehicles in Queue Work Zone Up

Comparison Option

No Comparison Compare with 10% More Volume Compare with 10% Less Volume

Show Analysis Results

- ❖ Lane closure condition
- ❖ Work-zone time plan
- ❖ Geometric condition
- ❖ Output type
- ❖ Options (input/output display, comparison)

Estimation Module (LCAP – Pro v 1.2)

Work-Zone Information

Please input work-zone information, then click the button to show analysis result.

Lane Closure Information

Number of lanes: 4 Number of open lane(s): 2 Lanes closed at: Right

Choose the Work Zone time

Start of Work-Zone: Monday 9:00 End of Work-Zone: Monday 12:00 Simulation Hours before start of Work_Zone: 2

Geometry Information (NDT in Scale)

On Ramp Off Ramp Ramp Info. Work_Zone Speed Limit 15 mph

Output Type

Queue Delay Show in red if QUEUE > 3.0 Miles Otherwise, show in yellow if QUEUE > 1.0 Miles

Display Option

Base Demand Approach Volume Roadway Volume Vehicles in Queue Work Zone Up

Comparison Option

No Comparison Compare with 10% More Volume Compare with 10% Less Volume

Ramp Information

UpStream Left Ramps

On Ramp Volume (VPH): 400

Percentage of vehicles existing Off Ramp: 10 %

Save and Close Cancel

- ✱ Allow to input detailed **geometry features**
 - Both before and after work zone
 - On-Ramp and off-Ramp
- ✱ Analyze using CORSIM

Output Module (LCAP – Pro v 1.2)

Analysis Report

	Start Time	End Time	Base Demand	Approach Volume	Roadway Volume	Vehicle in Queue	Queue Length (Miles)	WZ Up
1	Sun-23:00	Mon-0:00	3000	3000	3000	0	0	
2	Mon-0:00	Mon-1:00	1000	1000	1000	0	0	
3	Mon-1:00	Mon-2:00	1000	1000	1000	0	0	
4	Mon-2:00	Mon-3:00	1000	1000	1000	0	0	
5	Mon-3:00	Mon-4:00	1000	1000	1000	0	0	
6	Mon-4:00	Mon-5:00	1000	1000	1000	0	0	
7	Mon-5:00	Mon-6:00	1000	1000	1000	0	0	
8	Mon-6:00	Mon-7:00	1000	1000	1000	0	0	
9	Mon-7:00	Mon-8:00	4000	4000	4000	0	0	
10	Mon-8:00	Mon-9:00	4000	4000	4000	0	0	
11	Mon-9:00	Mon-10:00	5100	1356	5100	3744	4.92	X
12	Mon-10:00	Mon-11:00	5100	1356	8844	7488	9.85	X
13	Mon-11:00	Mon-12:00	5100	1356	12588	11232	14.77	X
14	Mon-12:00	Mon-13:00	7000	7200	18232	11032	14.51	
15	Mon-13:00	Mon-14:00	7000	7200	18032	10832	14.25	
16	Mon-14:00	Mon-15:00	7000	7200	17832	10632	13.98	
17	Mon-15:00	Mon-16:00	5000	7200	15632	8432	11.09	
18	Mon-16:00	Mon-17:00	5000	7200	13432	6232	8.2	
19	Mon-17:00	Mon-18:00	5000	7200	11232	4032	5.3	
20	Mon-18:00	Mon-19:00	5000	7200	9032	1832	2.41	
21	Mon-19:00	Mon-20:00	5000	6832	6832	0	0	
22	Mon-20:00	Mon-21:00	3000	3000	3000	0	0	
23	Mon-21:00	Mon-22:00	3000	3000	3000	0	0	

Save Results to CSV File

Return to Main

- ✿ **Input:** time, base demand, approach volume and roadway volume
- ✿ **Output:** vehicles in queue, queue length (miles) or delay (min), WZ up
- ✿ **WZ up**
 - “X” indicates that work zone is set up and in operations.
 - Help users to understand the impacts of work zone on traffic condition (i.e., queue formation)

Summary

✿ LCAP

- User friendly interface
- Help perform a quick analysis on freeway work zones
- Capable of running CORSIM with simple data input
- Capable of improving for any changes
 - Car following factors, rubber necking factors
- Capable of capturing impacts from ramps



THANK YOU!

For questions or technical support, contact us at ATTAP@umd.edu.

ATTAP research team
<http://attap.umd.edu>