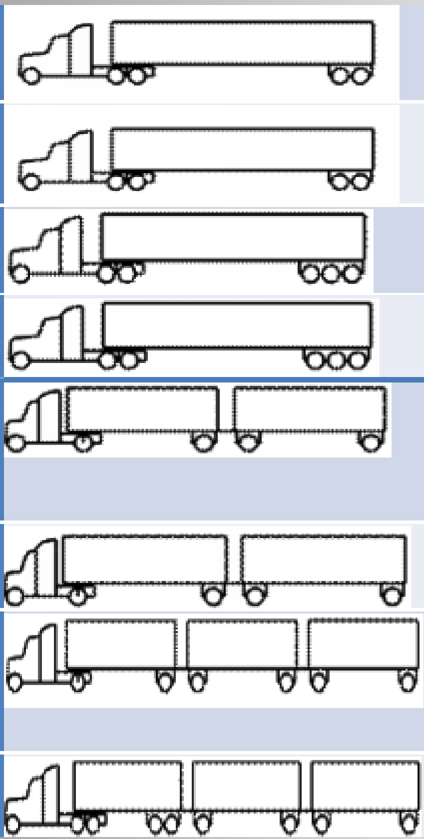
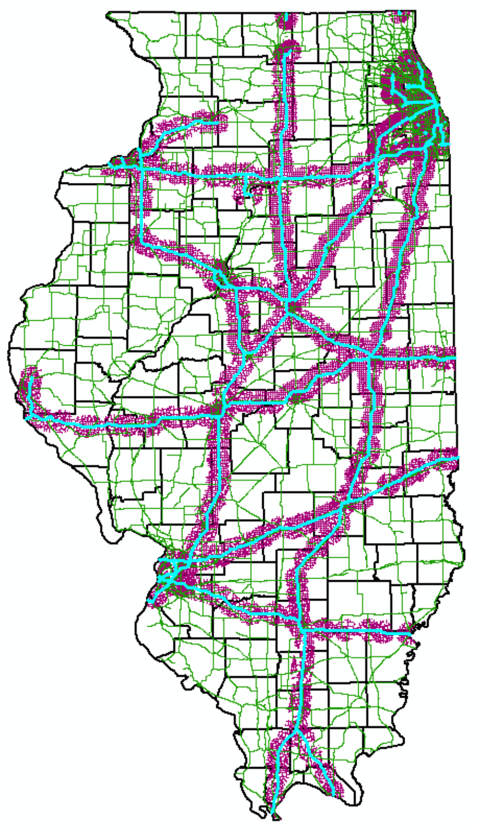
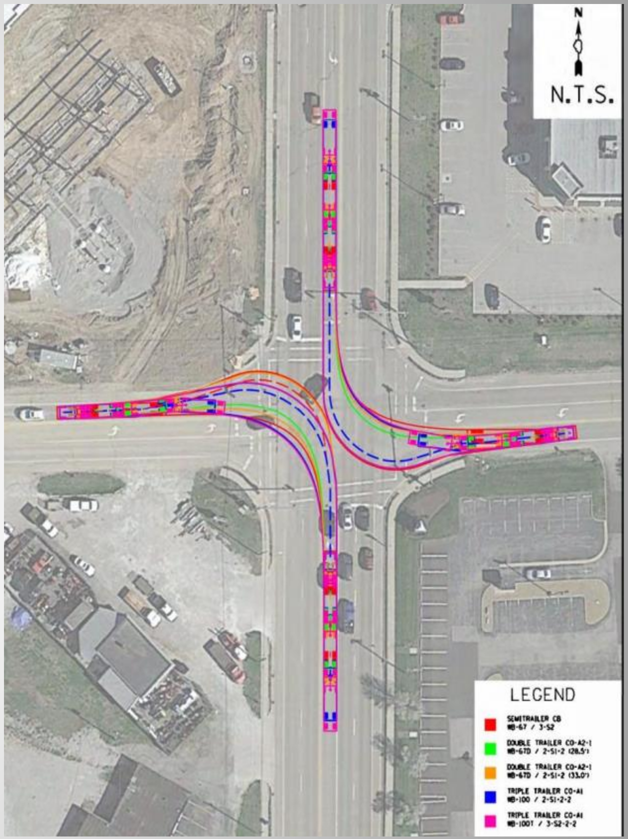
Illinois Comprehensive Truck Size & Weight Study Update



Control Single	80,000
1	88,000
2	91,000
3	97,000
Control Double	80,000
4	80,000
5	105,500
6	129,000





PM: Scott Sanford, P.E., S.E. **Tech. Lead: Chad Hodel, P.E., S.E.**

Assisted by Kaskaskia Engineering Group & Quigg Engineering

whks

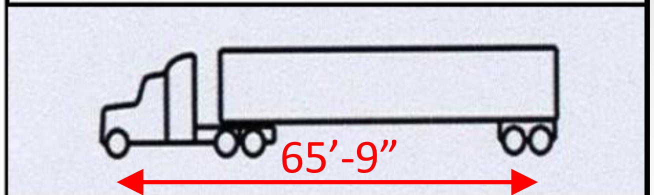
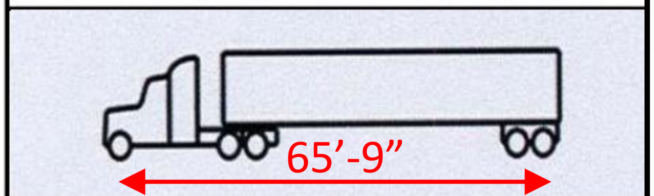
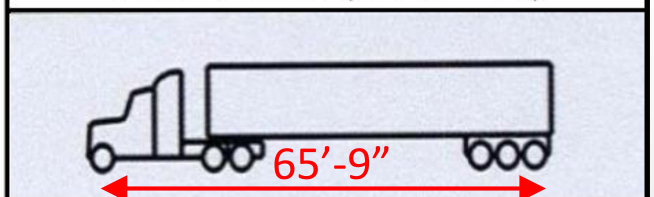
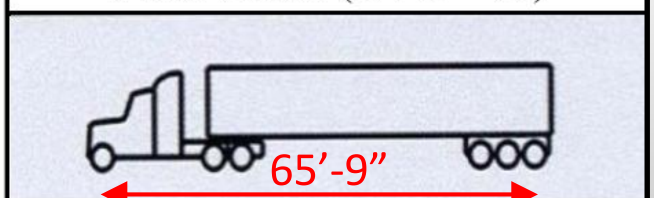
Project History

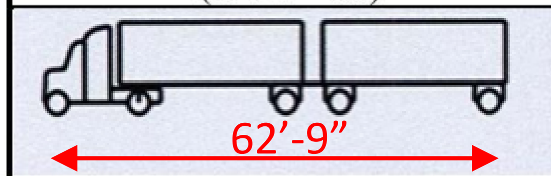
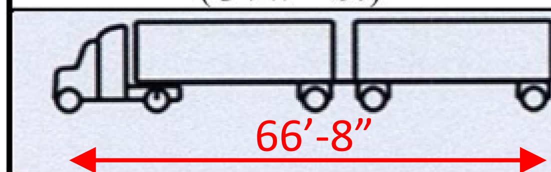
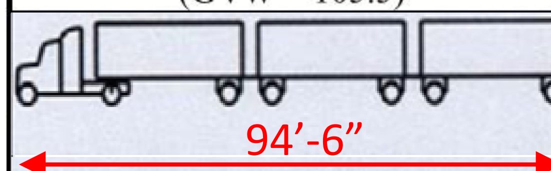
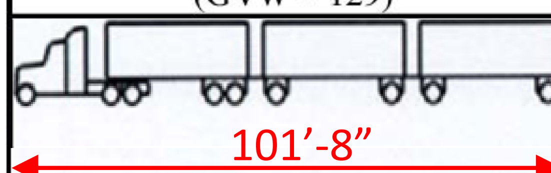
- 2012: MAP-21 Req'd a USDOT Comprehensive Truck Size & Weight Study
- Summer 2015: USDOT CTSWS Report

X – *Data limitations so profound that national impacts cannot be accurately predicted*

- TRB Review: More comprehensive/useful response possible w/in resources of the study
  - Inconsistent meas. of impact ≠ combined
  - Omission of roads not on interstate/national network
  - Omission of bridge deck costs

Alternative Truck Configurations

Control Vehicle CS5 (3S2) 12k SA – 17k	5-axle vehicle (GVW = 80)	 65’-9”
Truck 1 CS5 (3S2) ATC 1 12k SA – 19k	5-axle vehicle (GVW = 88)	 65’-9”
Truck 2 CS6 (3S3) ATC 2 12k SA – 15.8k	6-axle vehicle (GVW = 91)	 65’-9”
Truck 3 CS6 (3S3) ATC 3 12k SA – 17k	6-axle vehicle (GVW = 97)	 65’-9”

LCV Control Vehicle 2S1-2 (DS5) 12k SA – 17k	Tractor plus two 28-foot trailers (GVW = 80)	 62’-9”
Truck 4 2S1-2 (DS5) ATC 4 12k SA – 17k	Tractor plus two 33-foot trailers (GVW = 80)	 66’-8”
Truck 5 2S1-2-2 (DS7) ATC 5 12k SA – 15.6k	Tractor plus three 28-foot trailers (GVW = 105.5)	 94’-6”
Truck 6 3S2-2-2 (DS7+) ATC 6 12k SA – 14.6k	Tractor plus three 28-foot trailers (GVW = 129)	 101’-8”

whks

Project History

- IDOT study project approach presented July 2017
- Infrastructure $$ impact of 2012 MAP-21 alternative truck configurations (ATC's)

<u>Design Features</u>

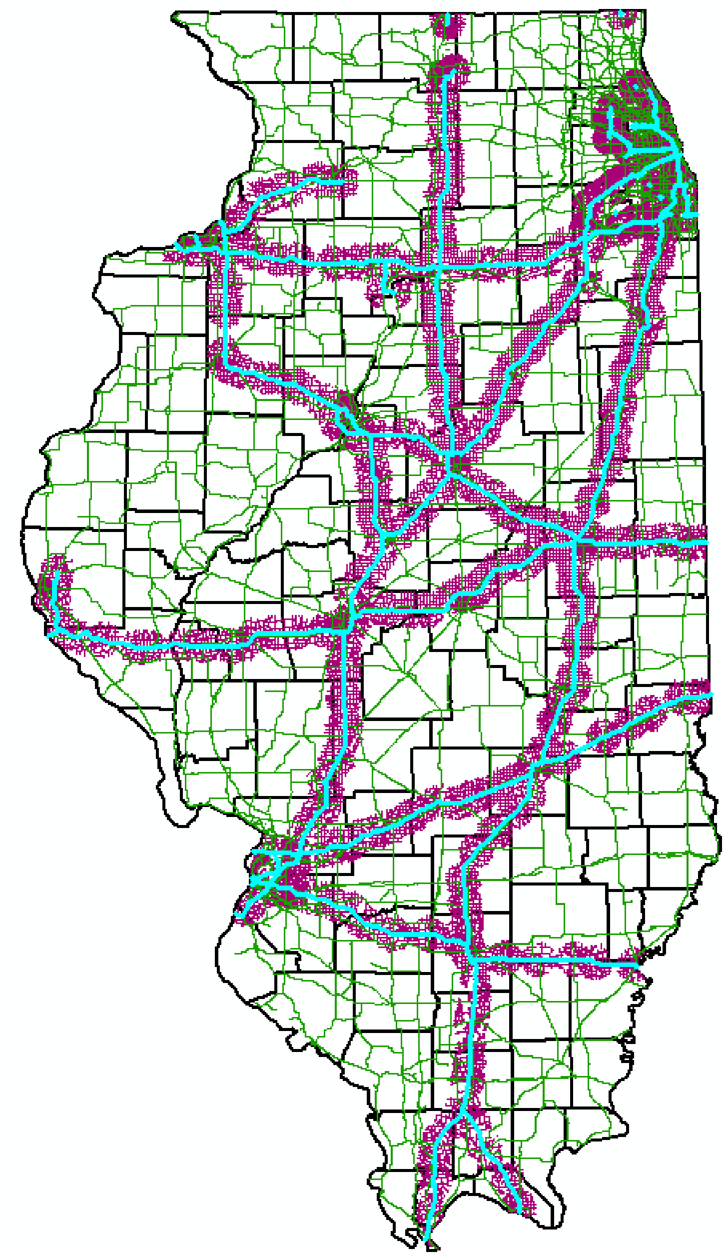
- Structures
- Pavements
- Geometrics
- Chokepoints

<u>Network Study</u>

- Interstates
- State Routes
- Local Roads w/in 5 Miles of Interchanges (*extrapolate to others)*

Proposed Project Approach

- Overcome USDOT limitations
- Provide 100% coverage of network study
- IL data driven study that facilitates the analysis of bulk data → extrapolate as necessary
- Analysis results linked to GIS



whks

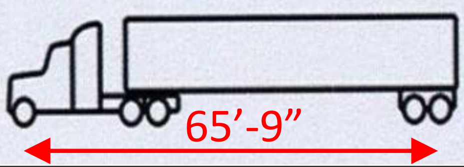
Modal Shift

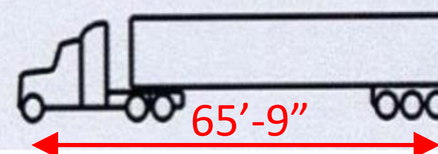
- Modal shift: Potential diversions in freight transport methods

- Intra-modal: Existing trucks → ATC's
- Inter-modal: Non-highway mode → ATC's

- ATC Variables:
  - Magnitude of truck size & weight
  - Frequency of trucks

Modal Shift

Control Vehicle CS5 (3S2) 12k SA – 17k	5-axle vehicle (GVW = 80)
	

Truck 3 CS6 (3S3) ATC 3 12k SA – 17k	6-axle vehicle (GVW = 97)
	

Modal Shift

- USDOT: Factors that affect Modal Shift
  - Size & weight of goods being shipped
  - Magnitude of commodities being shipped with various modes
  - Shipping logistics including origins/destinations
  - Propensity to substitute reduced shipping costs for increased commodities
  - Entire fleets not likely to be shifted to ATC’s
  - Price reductions from other modes to retain market share
  - →Complex!!!

whks

Modal Shift

- USDOT modal shift results presented as changes in Vehicle Miles Traveled (VMT's)
- Reported for each ATC as a function of operating weight
  - Example USDOT modal shift results:

Table 12: VMT Change by Operating Weight Distributions for Key Vehicle Configurations in Scenario 3 (Millions)

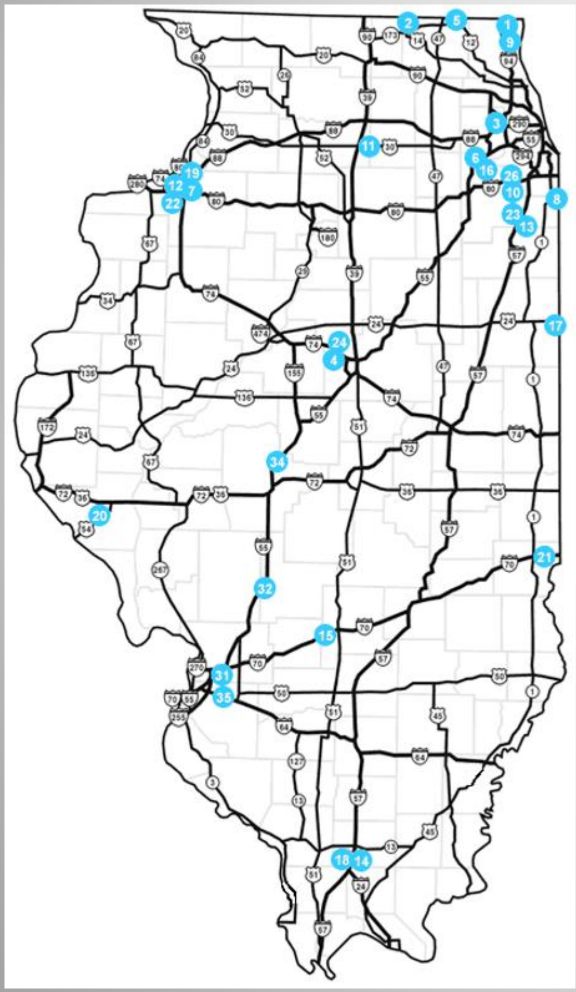
Operating Weight (lb.)	Base Case				Scenario 3			
	3-S2	Oth-CS5	3-S3	Total	3-S2	Oth-CS5	3-S3	Total
<= 62,000	66,315	8,389	1,183	75,888	66,315	8,389	1,183	75,888
62,001--68,000	10,872	1,784	175	12,831	10,872	1,784	175	12,831
68,001-74,000	13,593	2,584	187	16,364	13,593	2,584	187	16,364
74,001-80,000	14,356	2,711	219	17,286	4,729	899	584	6,213
80,001-86,001	5,597	1,018	181	6,796	637	116	3,759	4,512
86,001-92,000	1,684	305	141	2,129	195	35	6,060	6,291
92,001-98,000	661	115	97	874	398	69	6,724	7,191
>98,000	325	55	69	449	325	55	69	449
Total	113,952	17,050	2,351	133,353	97,613	14,021	18,841	130,475

Modal Shift

- Project approach: incorporate USDOT modal shift results
- WHKS: changes in VMT's considered to be reflection in number of vehicles on the roadway
  - Est. number of impacted truck types operating in IL within USDOT ATC weight ranges
  - Calc. USDOT modal shift factors to reflect shifts in traffic
  - Correlate to MU data (readily available info.)

Modal Shift

- Est. # of exist. impacted trucks w/ WIM data



IDOT WEIGH STATION INFORMATION				
Number	**Weigh Station Location / Name**	**Route**	**IDOT District**	**WIM Data**
1	Rosecrans SB	US 41	1	No
2	Harvard	US 14	1	No
3	Villa Park	IL 83	1	No
4	Carlock EB	I-74	3	Yes
5	Richmond	US 12	1	No
6	Bolingbrook SB	I-55	1	Yes
7	East Moline EB	I-80	2	Yes
8	Chicago Heights	US 30	1	No
9	Wadsworth	US 41	1	No
10	Frankfort WB	I-80	1	Yes
11	Compton	US 30	2	No
12	Moline WB	I-74/280	2	Yes
13	Peotone NB	I-57	1	Yes
14	Marion NB	I-57	9	Yes
15	Brownstown EB	I-70	7	Yes
16	Bolingbrook NB	I-55	1	Yes
17	Sheldon	US 24/52	3	No
18	Marion SB	I-57	9	Yes
19	East Moline WB	I-80	2	Yes
20	Pittsfield	US 36/54	6	No
21	Marshall WB	I-70	5	Yes
22	Moline EB	I-74/280	2	Yes
23	Peotone SB	I-57	1	Yes
24	Carlock WB	I-74	3	Yes
26	Frankfort EB	I-80	1	Yes
31	Maryville WB	I-55/70	8	Yes
32	Litchfield	I-55	6	Yes
34	Williamsville SB	I-55	6	Yes
35	O'Fallon EB	I-64	8	Yes

Modal Shift

- WIM results for each IDOT District avg.’d
- ATC’s 1-3 for District 8 shown below
- ATC’s 4-6 & other Districts similar

ESTIMATED MODAL SHIFT RESULTS - DISTRICT 8 AVERAGE													
Item		ATC Scenario #											
		1				2				3			
		Avg.	Max.	Min.	Std. Dev.	Avg.	Max.	Min.	Std. Dev.	Avg.	Max.	Min.	Std. Dev.
3-S2 Leaving	# Trucks	15,292	52,524	459	7,498	10,769	27,371	836	4,024	11,276	38,617	337	5,560
	% MU's	12.63	30.85	0.31	4.51	9.09	15.15	0.58	2.04	9.30	22.68	0.22	3.35
Oth-CS5 Leaving	# Trucks	61	218	2	38	1,371	3,484	98	652	1,353	4,847	28	840
	% MU's	0.05	0.15	0.00	0.02	1.14	2.37	0.07	0.38	1.10	3.39	0.02	0.53
3-S2 Entering	# Trucks	13,962	48,186	411	6,982								
	% MU's	11.51	27.39	0.27	4.20								
3-S3 Entering	# Trucks					11,178	28,411	880	4,270	10,749	36,996	315	5,411
	% MU's					9.43	15.32	0.60	2.18	8.85	22.19	0.21	3.26

Pavement

- Service Life ←→ Axle Weight ←→ Frequency
- USDOT: AASHTO *Pavement ME Design Software*
  - Δ in traffic, time, distress (rutting, faulting, etc.)

  X – does not analyze asphalt overlays (OL)

  - Δ Orig. Life → 12 year OL → 12 year OL……

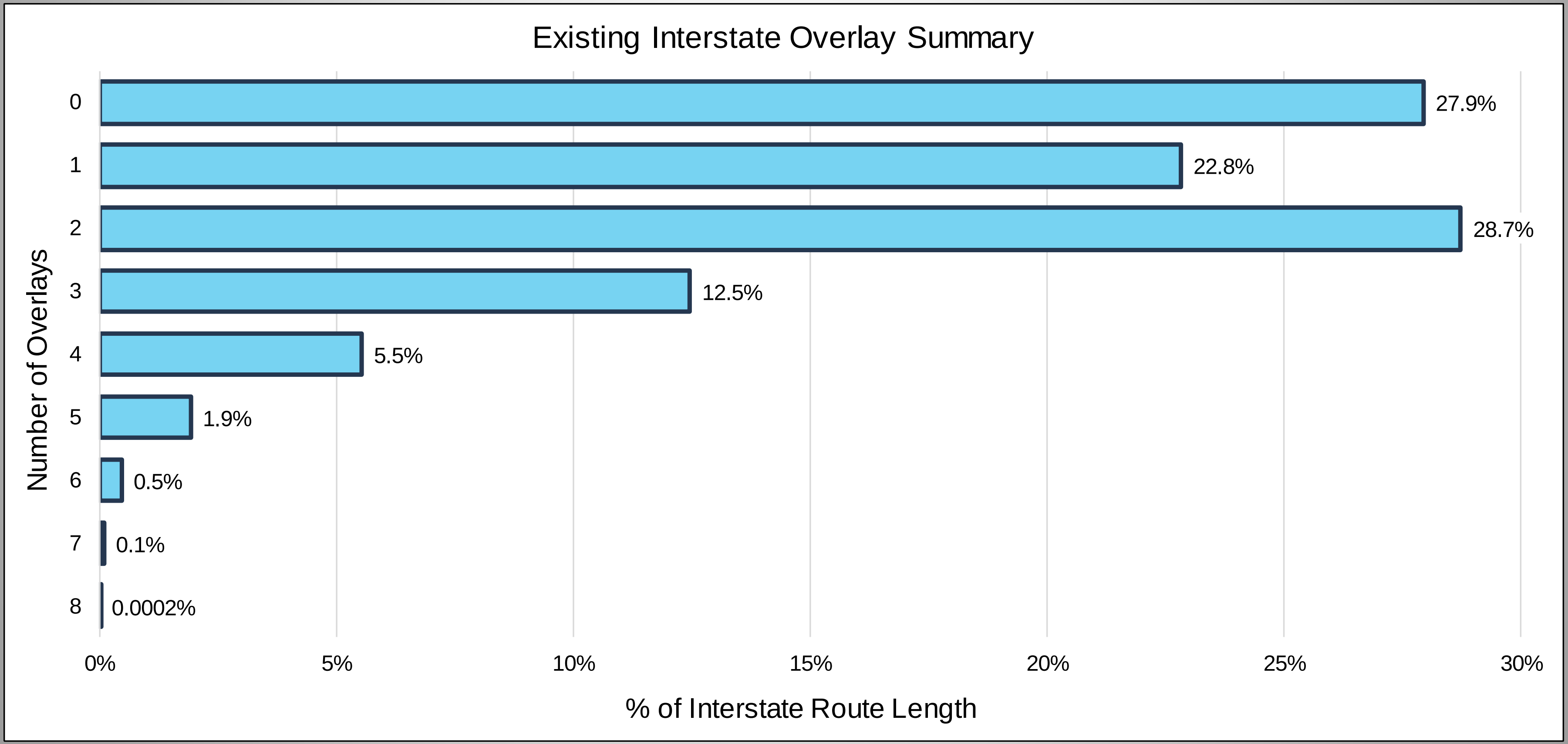
Table 12: Service Interval and Life Cycle Cost Percent Changes by Scenario

Scenario	1	2	3	4	5	6
% Change in Service Interval	-0.3	+2.7	+2.7	-1.6	-0.0	-0.1
% Change in LCC	+0.4 to +0.7%	-2.4 to -4.2%	-2.6 to -4.1%	+1.8 to +2.7%	+0.1 to +0.2%	+0.1 to +0.2%

X – Cannot combine results w/ other cost impacts

Pavement

- Why is OL performance of interest for IL study?



Pavement

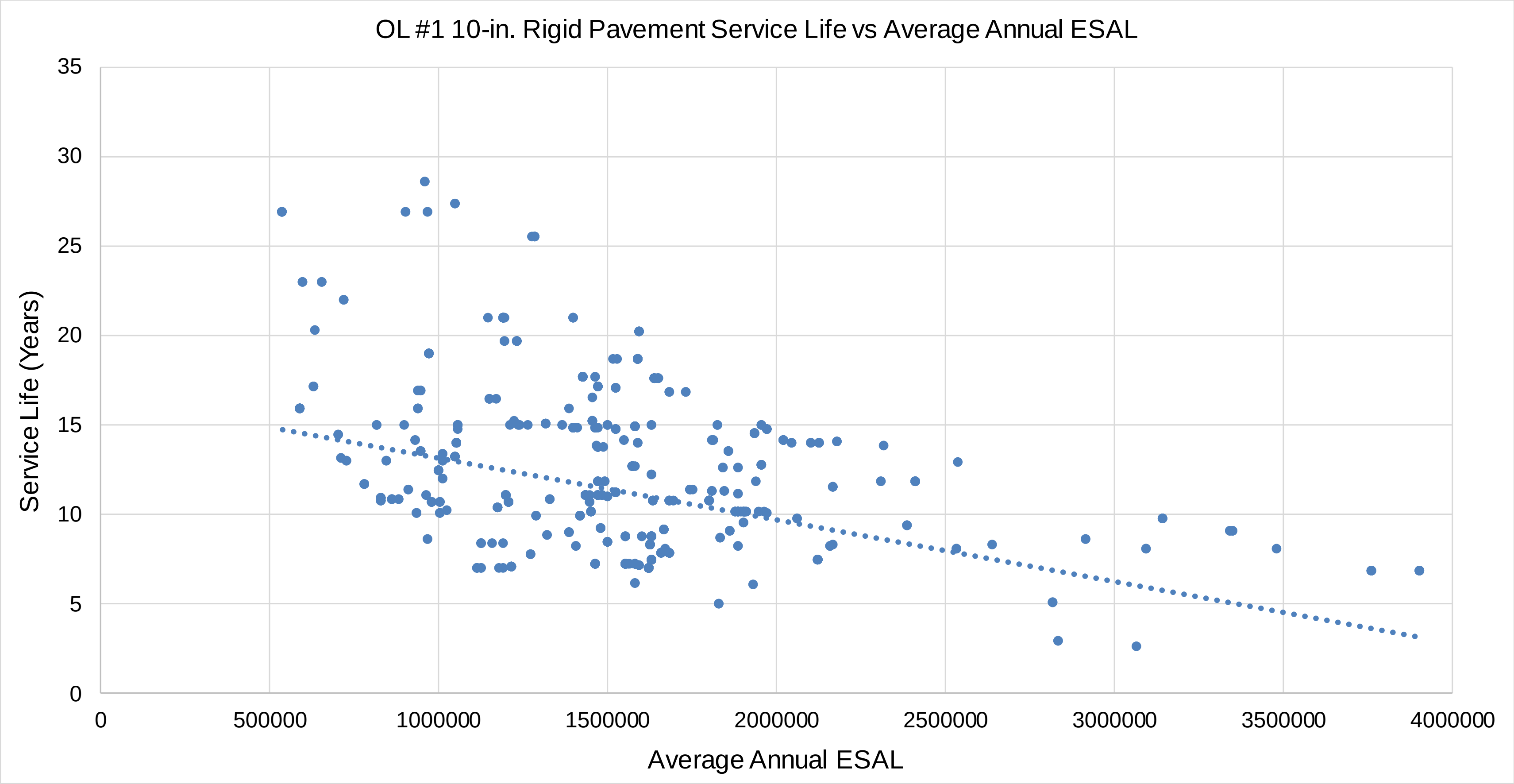
- Fortunate that IDOT Bureau of Research has a large database of interstate data
  - Construction history:
    - Original pavement type & completion date
    - Overlay history & date
  - Traffic history
    - PV, SU, & MU
    - Design lane distribution factors
- → *Facilitates an IL data driven analysis*

Pavement

- IL data assessments of orig. pavement and subsequent OL's
  - Service life (years)
  - Traffic loading (ESAL's)
- Equivalent Single Axle Loadings
  - Indication of # of axle load repetitions
  - Various vehicles normalized to an 18 kip axle load

Pavement

- Example of historical data analysis
  - Trends of decreased service life w/ increased ESAL

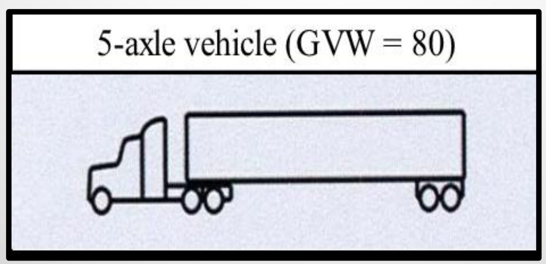


whks

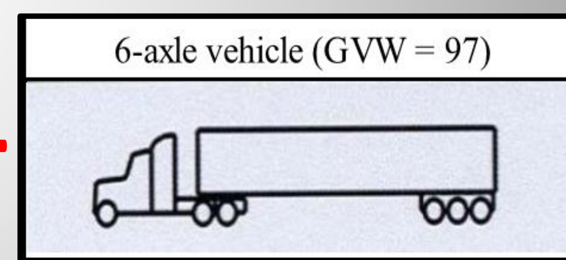
Pavement

- Interstate Pavement Analysis Procedure
  - Forecast traffic data to 2060
  - Calculate ESAL each year for exist. traffic configuration
  - Recalc. ESAL each year for ATC & Modal Shift by modifying exist. ESAL

-



+

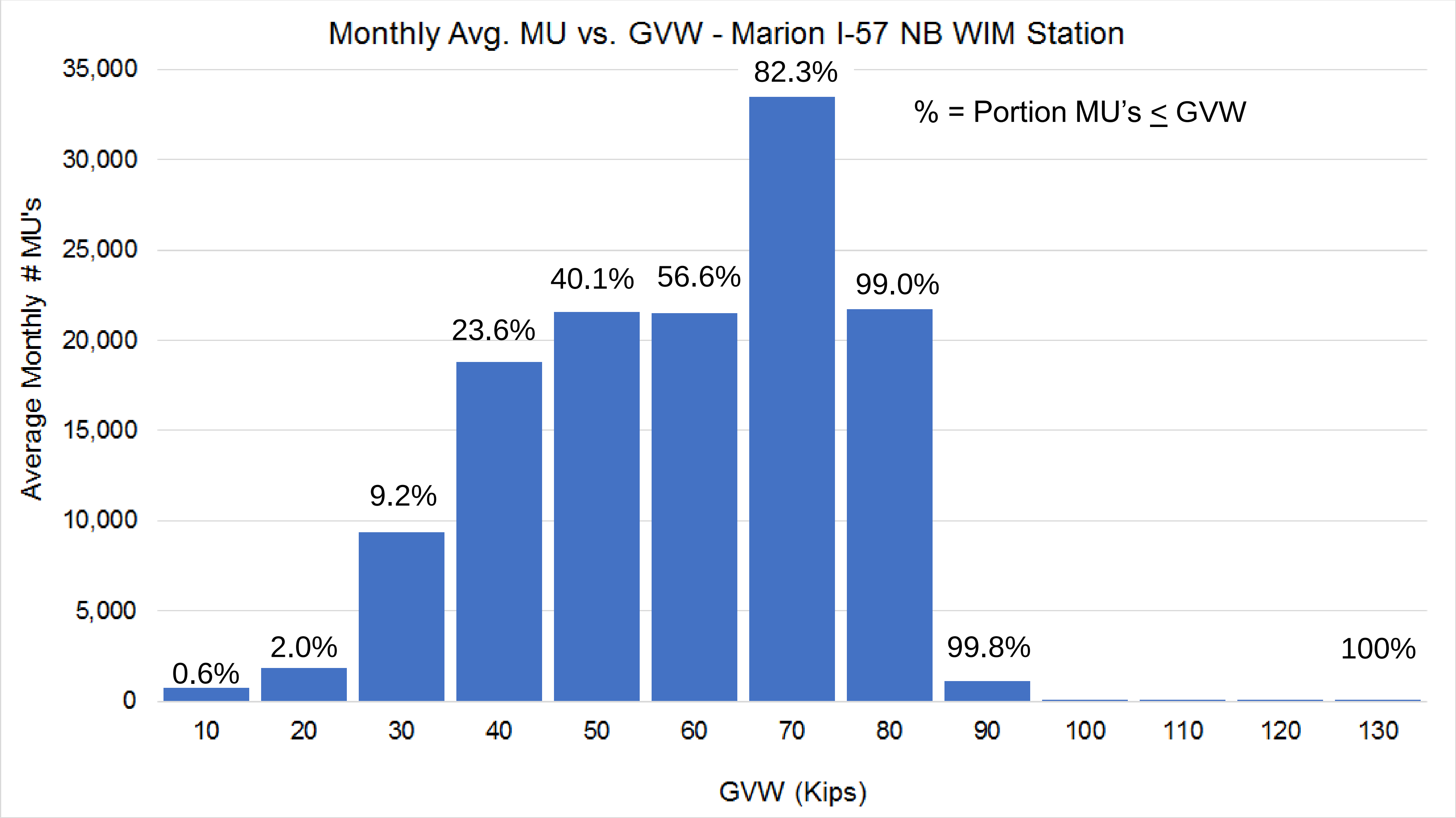


Exist. Avg. MU
$ESAL = 1.91*MU$

Exist. CV Leaving
$ESAL = 3.50*CV_L$

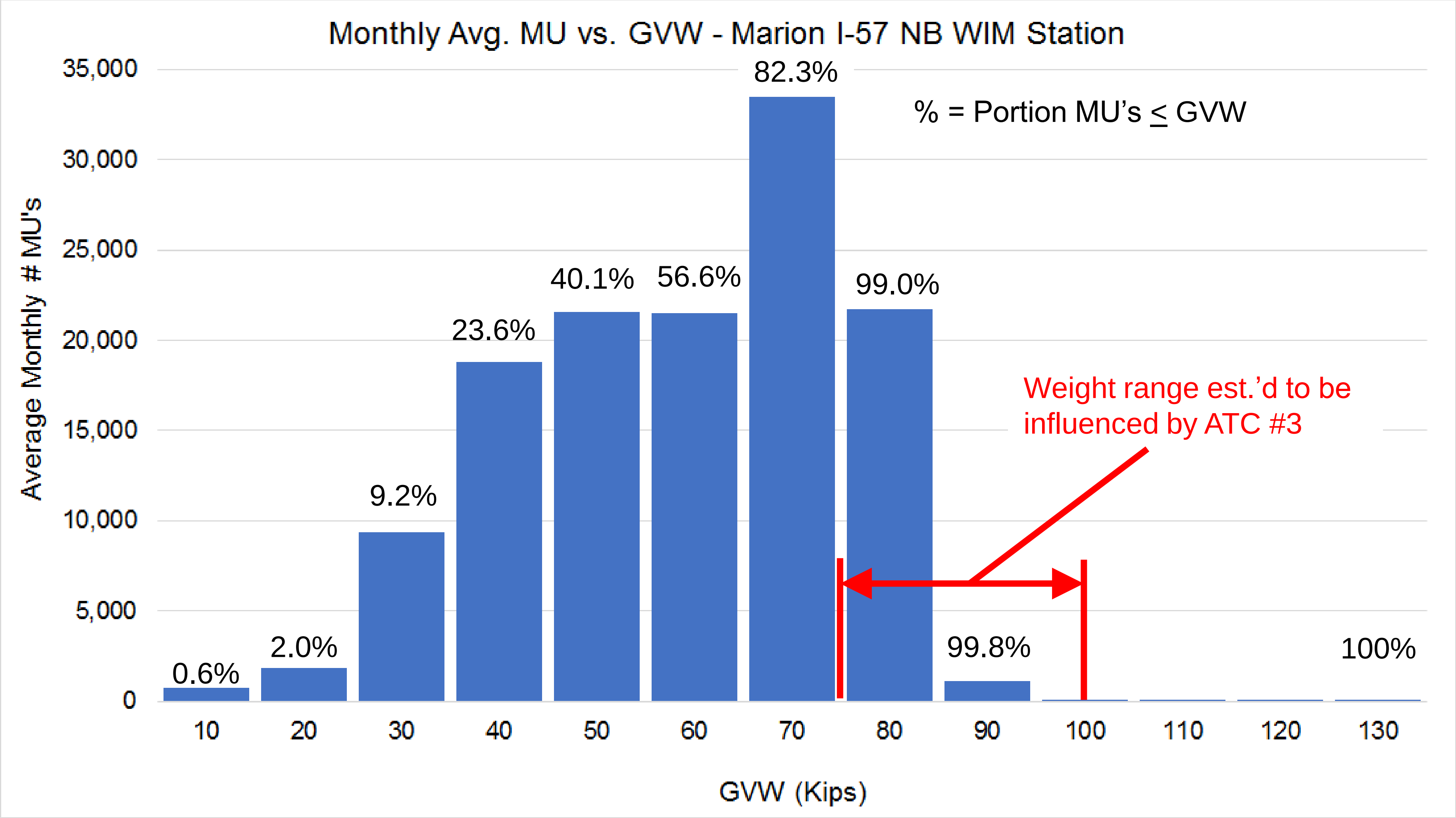
ATC #3 Entering
$ESAL = 4.80*ATC_E$

Pavement



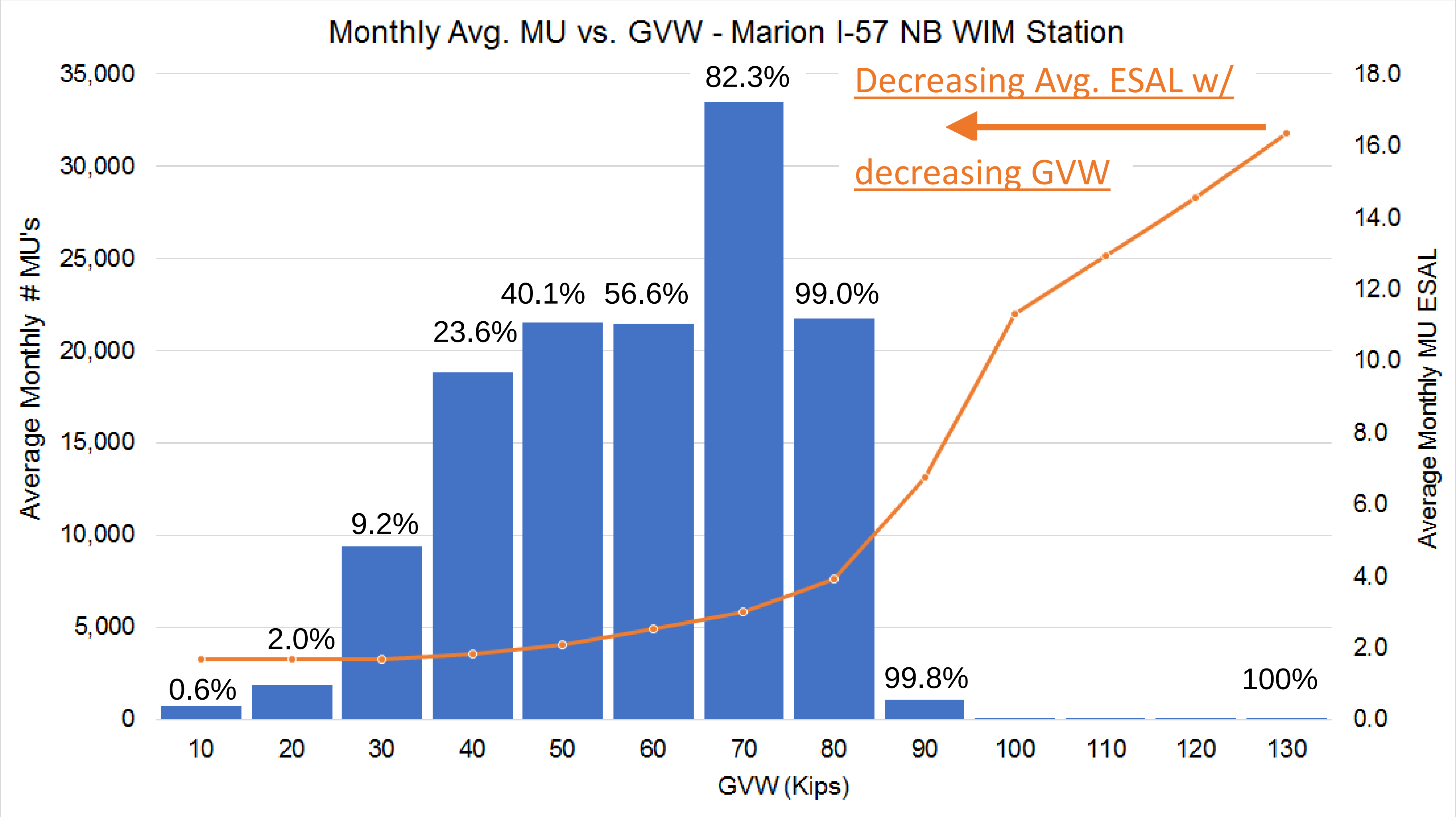
whks

Pavement



Monthly Avg. MU vs. GVW - Marion I-57 NB WIM Station
Average Monthly # MU's
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
GVW (Kips)
0.6%
2.0%
9.2%
23.6%
40.1%
56.6%
82.3%
99.0%
99.8%
100%
% = Portion MU's ≤ GVW
Weight range est.'d to be influenced by ATC #3

Pavement


Monthly Avg. MU vs. GVW - Marion I-57 NB WIM Station
Decreasing Avg. ESAL w/ decreasing GVW
Average Monthly # MU's
Average Monthly MU ESAL
GVW (Kips)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
10
20
30
40
50
60
70
80
90
100
110
120
130
0.6%
2.0%
9.2%
23.6%
40.1%
56.6%
82.3%
99.0%
99.8%
100%

Pavement

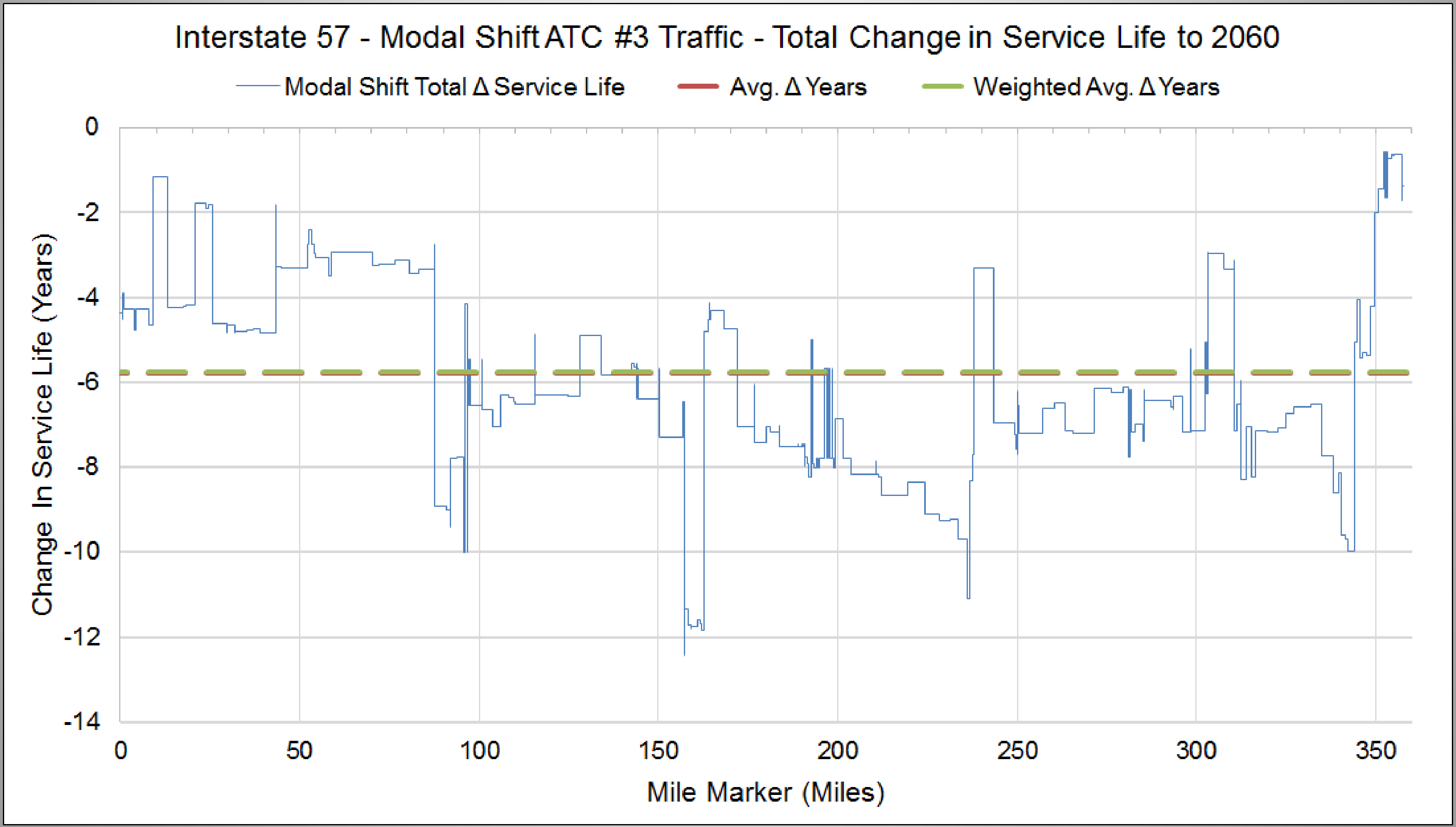
- Historical performance data used to calc. service lives of orig. pavement/OL’s through 2060
  - ESAL’s of exist. traffic configuration
  - ESAL’s w/ modal shift and ATC’s

- Δ Total = Δ Orig. Pav’t + Δ OL #1 + Δ OL #2 +….

- Δ OL #2 = Serv. Life (Exist.) – Serv. Life (ATC)

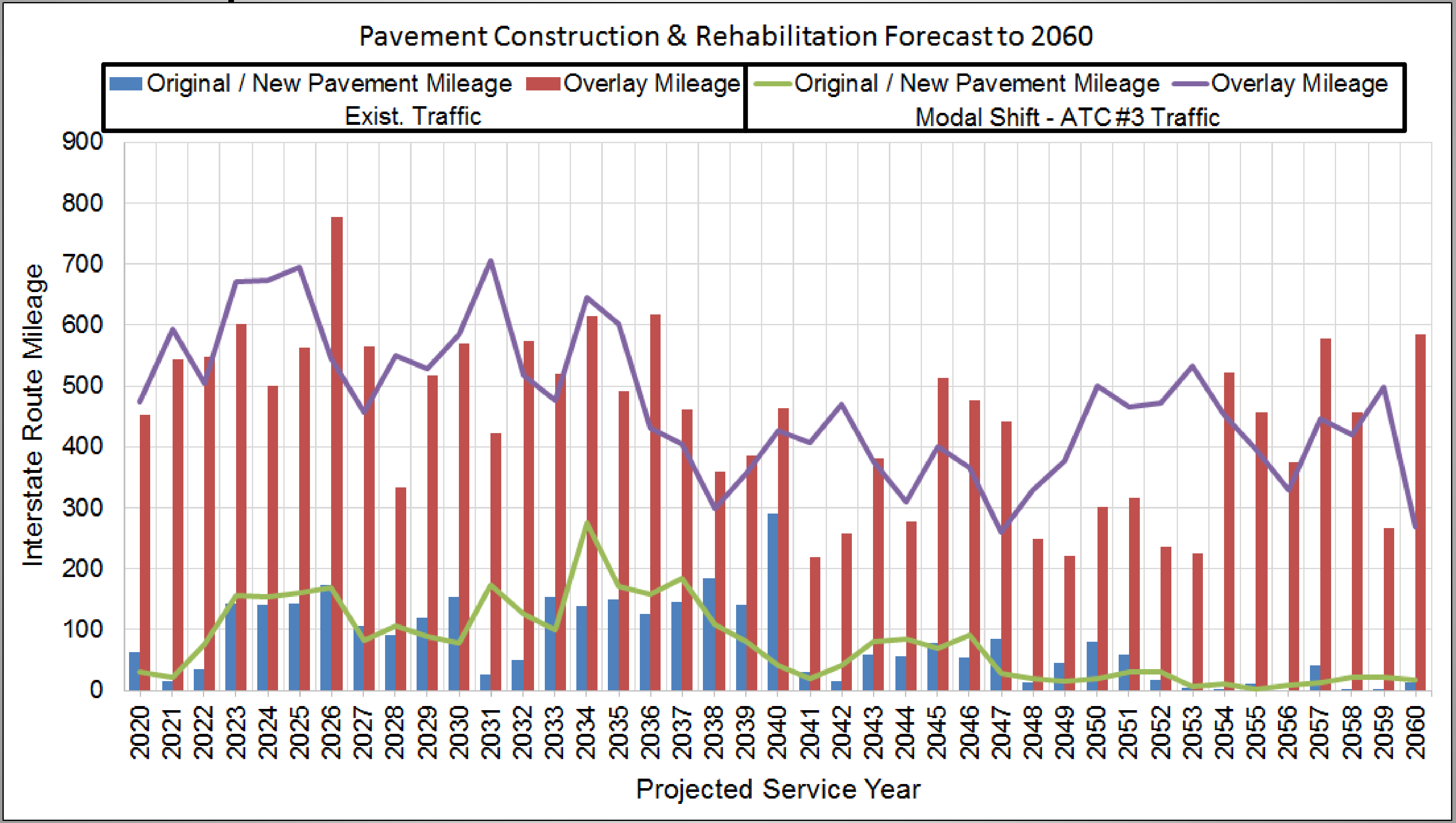
Pavement

- Example Prelim. Interstate Results - Route Specific - ATC #3



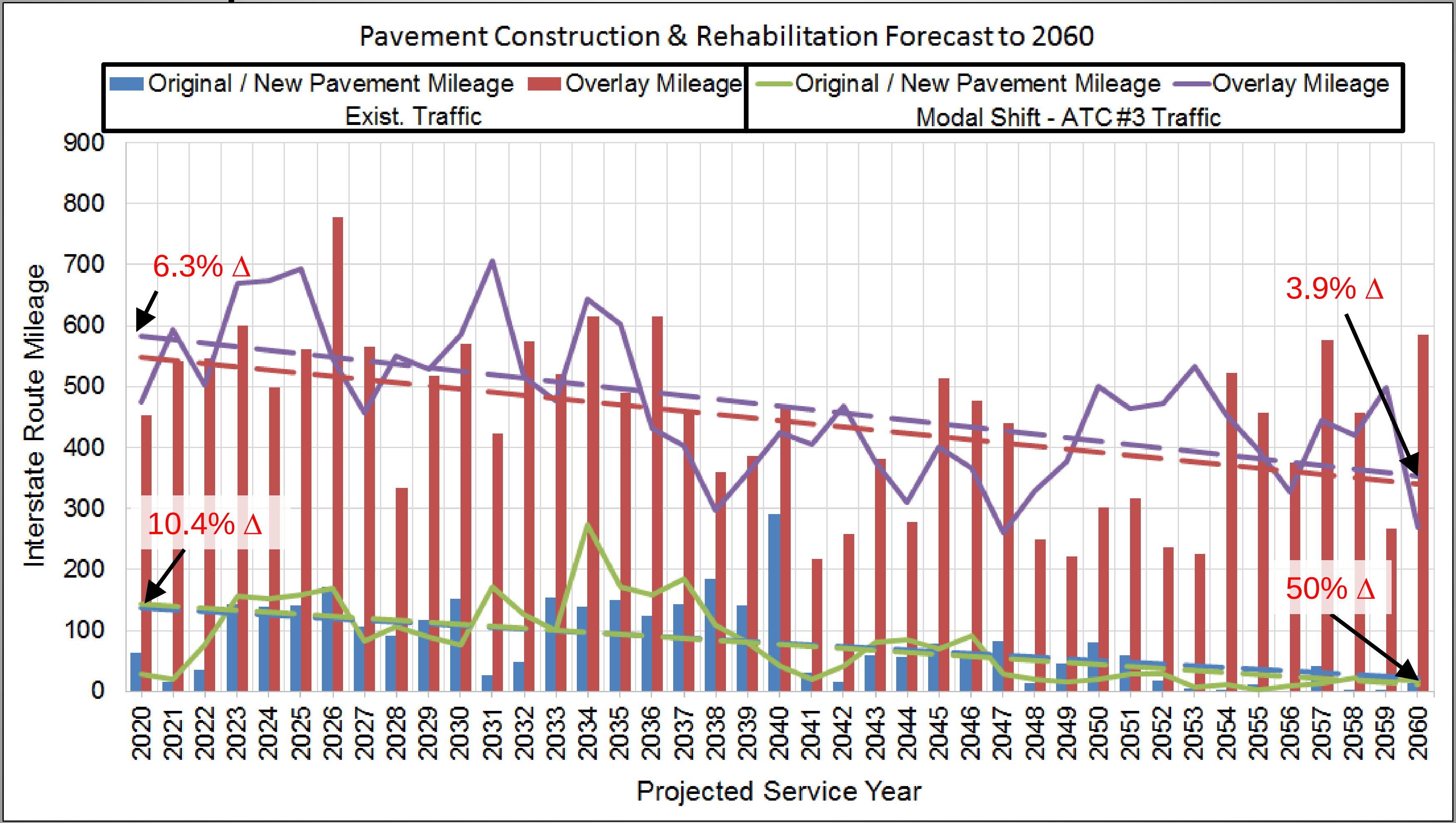
Pavement

- Example Prelim. Results for All Interstates



Pavement

- Example Prelim. Results for All Interstates



Pavement

- State Routes:
  - Quality of historical data is not nearly as good as for interstate routes
  - Rather than contract data, spans of past service lives based upon significant jumps in Condition Rating Survey data
  - Performing an analysis similar to the interstates
- Local Roads:
  - Data is significantly lacking
  - Working to potentially estimate cost impacts using a database of historical maintenance costs

Geometrics

- Analysis of Interchanges & Intersections
- Ability to accommodate ATC turning characteristics
- Potential of ATC's to impede traffic flow
- Intersection/Interchange Level Of Service:
  - Traffic quality ←→ given flowrate
- LOS: A → F → speed, travel time, density, etc.
- As LOS decreases → potential chokepoint

Geometrics

- Facilities Analyzed:
  - – 24 Interchanges
  - – 30 Intersections
- Various types and control methods

Geometrics

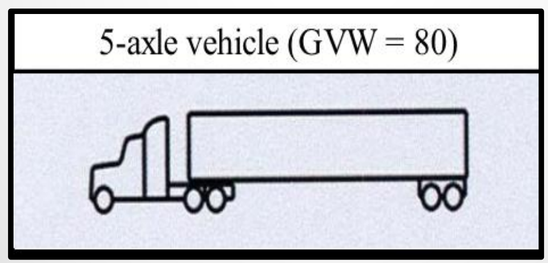
- Key parameter for assessing LOS:
- Demand flow rate, $v_p = \dfrac{V}{PHF \times N \times f_{HV} \times f_p}$
- V = demand volume
- f_{HV} = heavy vehicle factor

  → assigns Passenger Car Equivalent values to truck traffic (longer, heavier, slower)
- $0 < f_{HV} \leq 1.0$
- Truck traffic ↑ → f_{HV} ↓ → v_p ↑

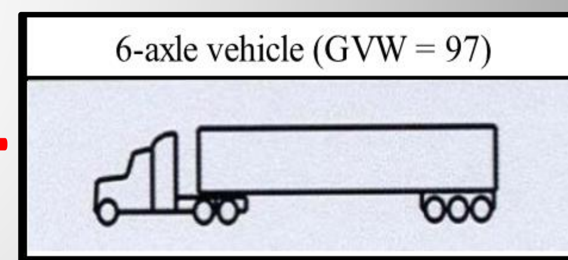
Geometrics

- Default Avg. PCE = 1.5 (reflects avg. truck traffic)
- Modal Shift Analysis: impacted trucks heavier than avg.→ PCE > 1.5
- Sample f_{HV} modification (qualitative example):

-



+



Exist. Avg. MU
1.5*MU

Exist. CV Leaving
$PCE_{CV} * CV_L$

ATC Entering
$PCE_{ATC} * ATC_E$

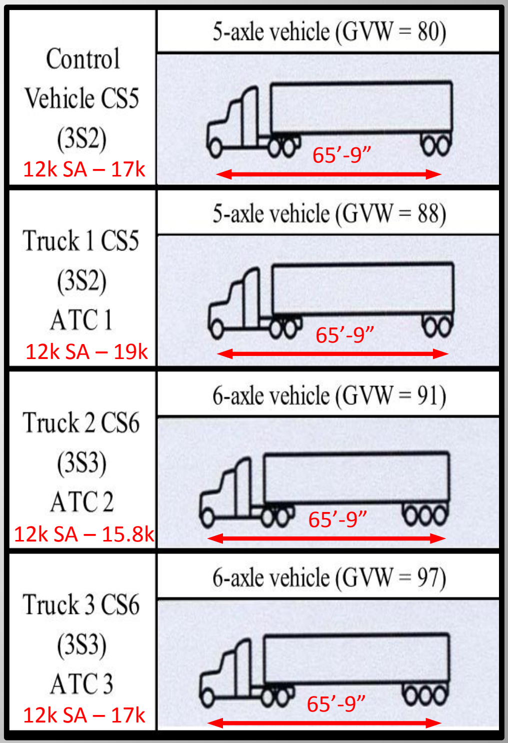
Geometrics

- Sample f_{HV} modification:

$$f_{HV} = \frac{\text{Exist. Avg. MU}}{\mathbf{1.5} * MU} - \frac{\text{Exist. CV Leaving}}{PCE_{CV} * CV_L} + \frac{\text{ATC Entering}}{PCE_{ATC} * ATC_E}$$

- For ATC's 1-3, no change in W/HP → $PCE_{CV} = PCE_{ATC}$ (no Δ length)
  - f_{HV} only affected Δ # trucks
- IF a base HP of 485 is assumed:

PCE: Rural 4-Lane Interstate - 0% Grade	
CV #1	2.7
ATC #1	2.9
ATC #2	2.9
ATC #3	3.1



Geometrics

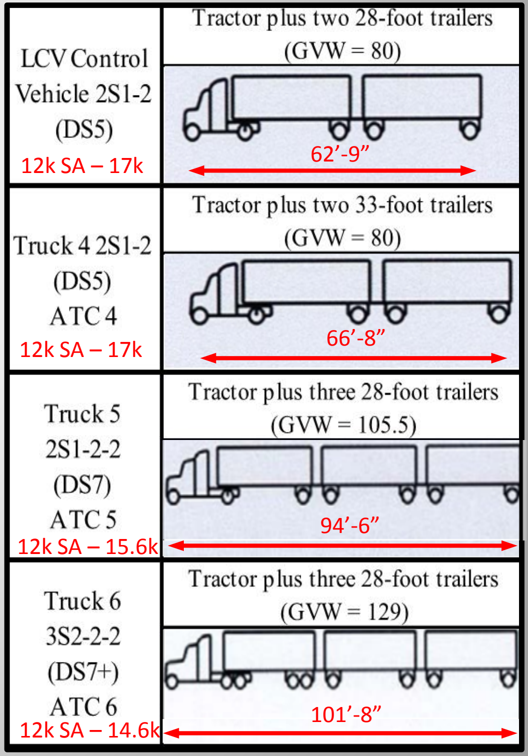
$$f_{HV} = \frac{\text{Exist. Avg. MU}}{\mathbf{1.5}*MU} - \frac{\text{Exist. CV Leaving}}{PCE_{CV}*CV_L} + \frac{\text{ATC Entering}}{PCE_{ATC}*ATC_E}$$

- For ATC's 4-6, no change in W/HP (note Δ length)

PCE: Rural 4-Lane Interstate - 0% Grade	
CV #2	2.6
ATC #4	2.7
ATC #5	3.2 (HP=588)
ATC #6	3.6 (HP=588)

- IF a base HP of 485 is assumed:

PCE: Rural 4-Lane Interstate - 0% Grade	
CV #2	2.6
ATC #4	2.7
ATC #5	3.5
ATC #6	3.8 (HP=520)

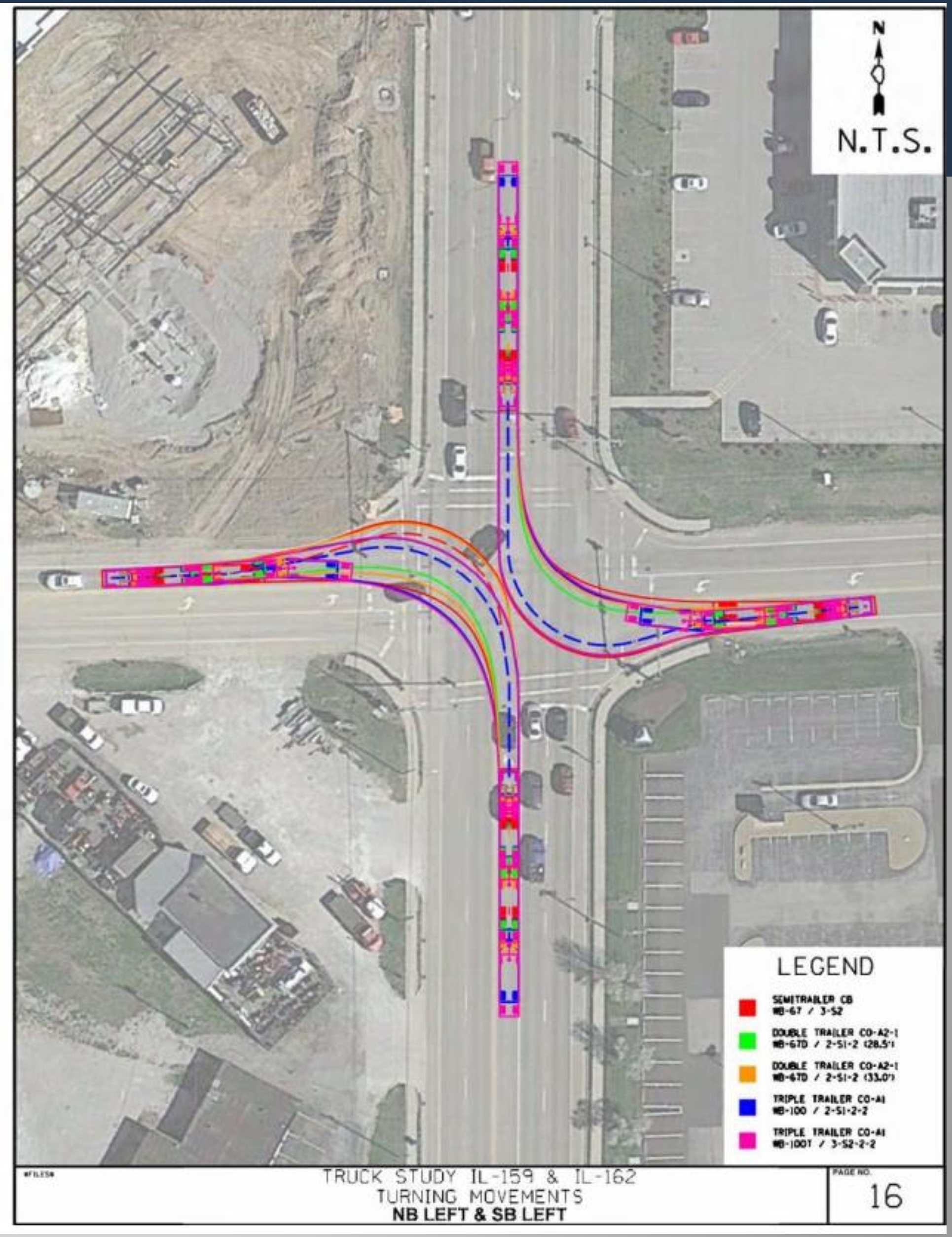


Geometrics

- Capacity Analysis Results:
  - Est. modal shift & Δ key parameters not significant enough to cause an appreciable Δ's in time in where there are shifts in the LOS
  - Req'd modal shift to change f_{HV} and LOS is substantially greater than USDOT prediction

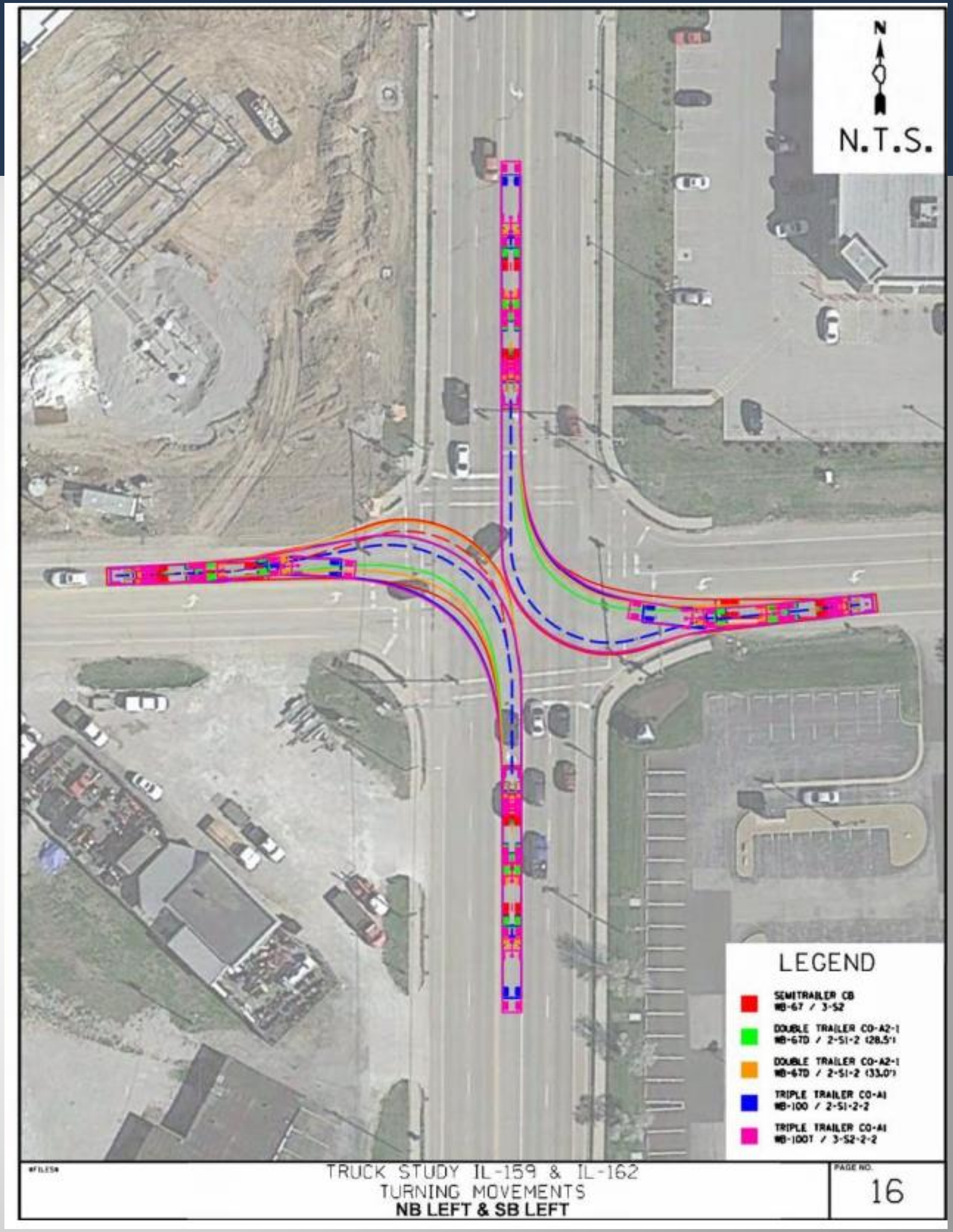
Geometrics

- Operational Characteristics
  - Navigating turns
  - Lane encroachment
  - Wheel dropping
- AutoTurn Analysis



Geometrics

- AutoTurn Analysis:
  - ATC swept path typ. enveloped by CV's
  - Generally <u>no net effect</u> of the ATC's



Structures

- Assuming legislative acceptance of ATC's → "Routine Commercial Traffic" (Legal Loads)
- Fortunate that IDOT maintains a comprehensive bridge rating database

    → Attempted to rate nearly every state maintained structure modeled in database

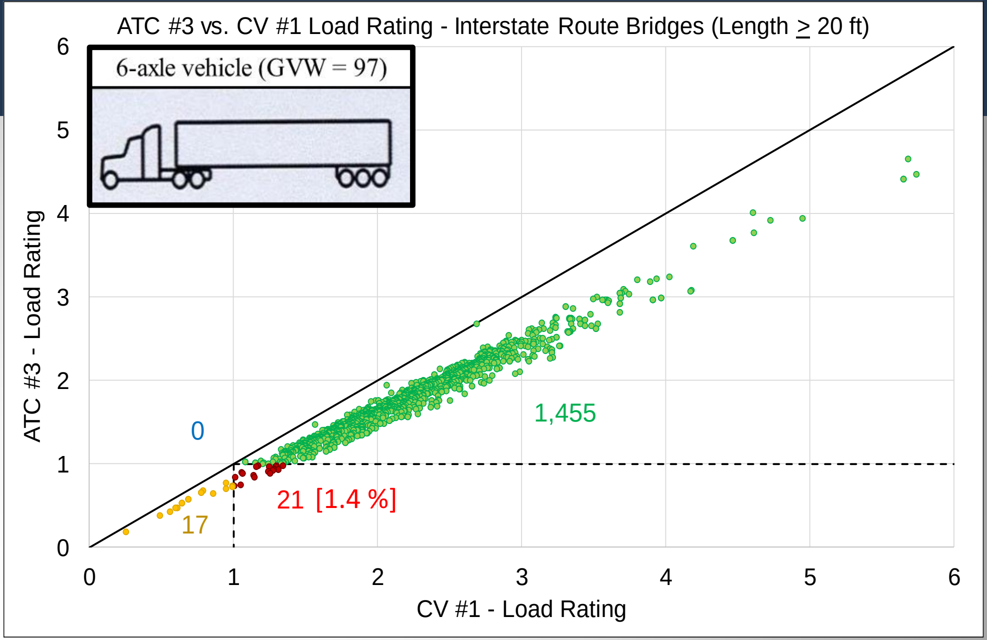
    → Approx. 6,000 structures

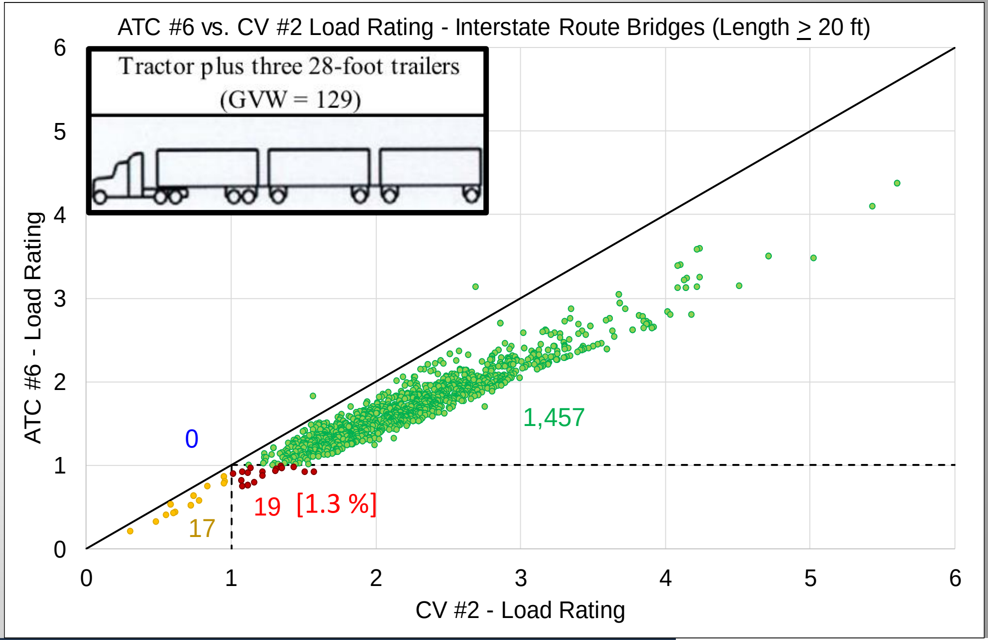
    → Primarily focus on structures > 20 ft length

- Local Roads: rated approx. 1,450 structures → extrapolated ratings to 14,950 structures

Structures

- Interstates
- ATC/CV Rating Factor Ratios

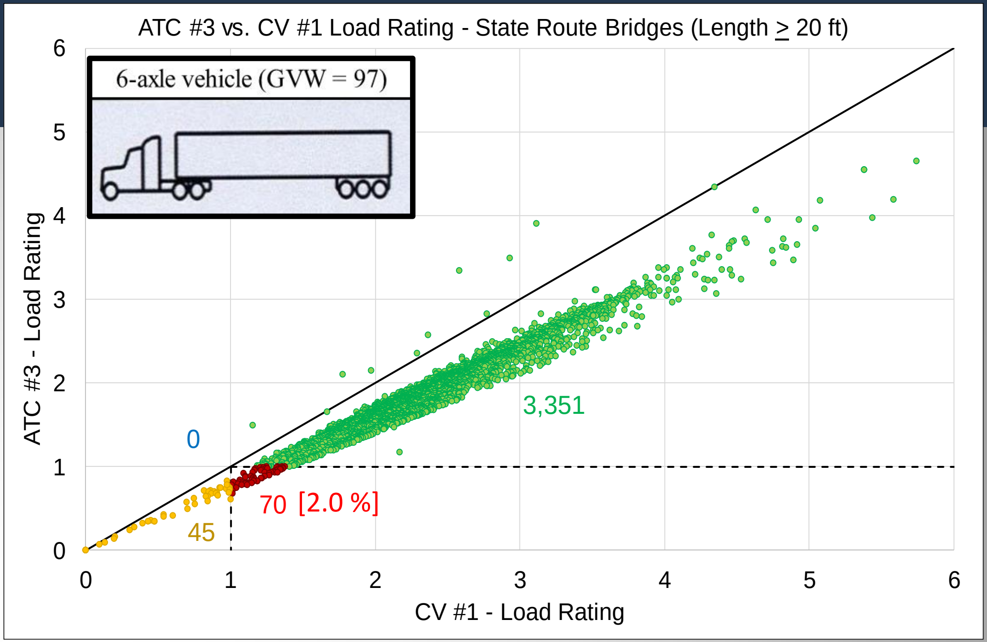


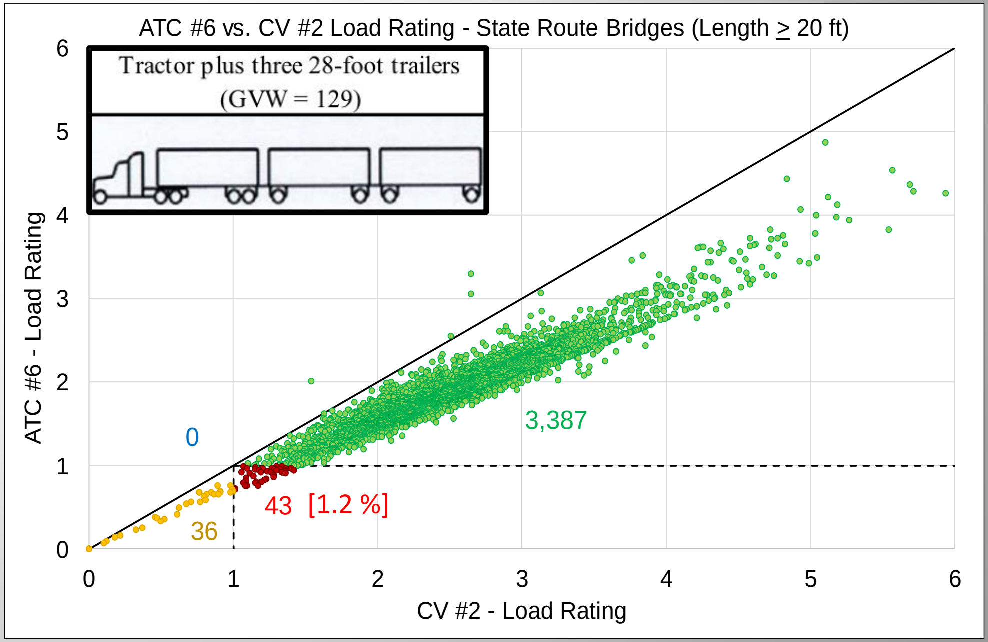


- ATC-RF ≥ 1.0, CV-RF ≥ 1.0
- ATC-RF < 1.0, CV-RF ≥ 1.0
- ATC-RF < 1.0, CV-RF < 1.0
- ATC-RF ≥ 1.0, CV-RF < 1.0

Structures

- State Routes
- ATC/CV Rating Factor Ratios

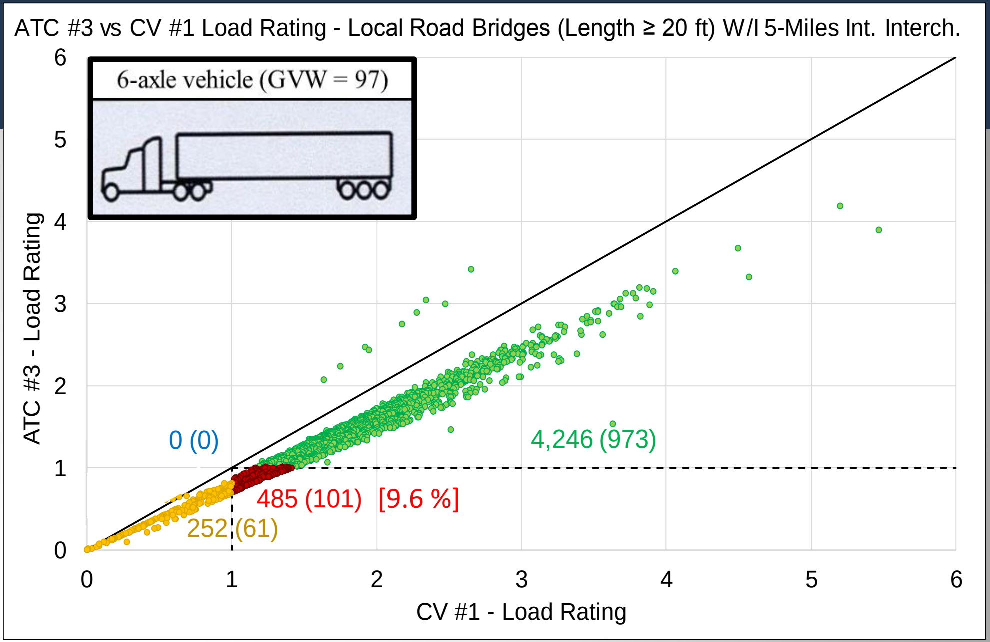


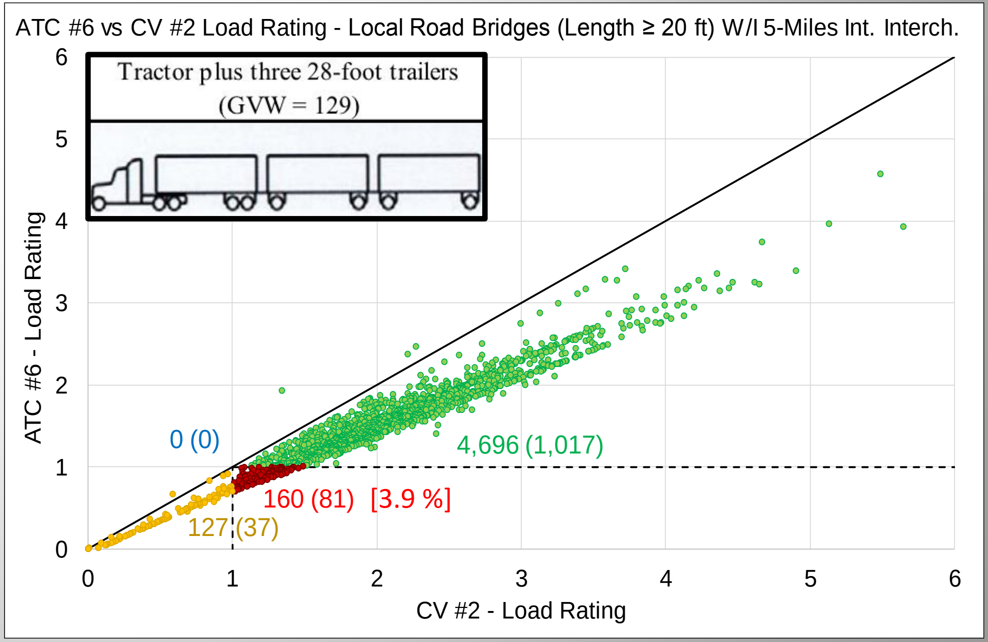


- ATC-RF ≥ 1.0, CV-RF ≥ 1.0
- ATC-RF < 1.0, CV-RF ≥ 1.0
- ATC-RF < 1.0, CV-RF < 1.0
- ATC-RF ≥ 1.0, CV-RF < 1.0

Structures

- Local Roads w/in 5-miles of interchanges
- ATC/CV Rating Factor Ratios
- (__) = Software Rated
- __ = Extrapolated Rating

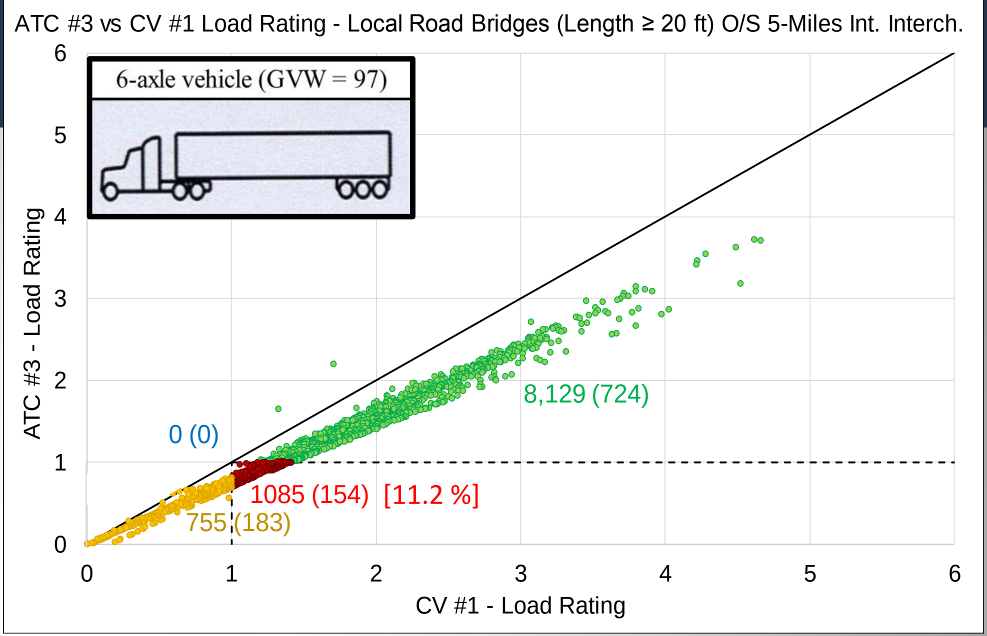


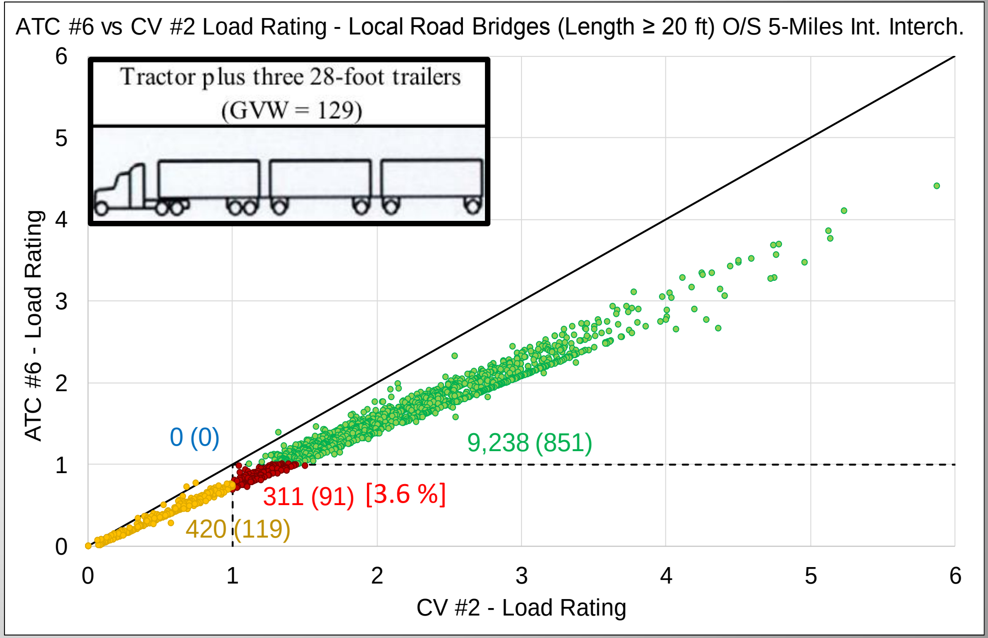


- ATC-RF ≥ 1.0, CV-RF ≥ 1.0
- ATC-RF < 1.0, CV-RF ≥ 1.0
- ATC-RF < 1.0, CV-RF < 1.0
- ATC-RF ≥ 1.0, CV-RF < 1.0

Structures

- Local Roads <u>o/s 5-miles</u> of interchanges
- ATC/CV Rating Factor Ratios
- (__) = Software Rated
- __ = Extrapolated Rating





- ATC-RF ≥ 1.0, CV-RF ≥ 1.0
- ATC-RF < 1.0, CV-RF ≥ 1.0
- ATC-RF < 1.0, CV-RF < 1.0
- ATC-RF ≥ 1.0, CV-RF < 1.0

Structures

- Bridge Decks:

X-USDOT: *no readily accepted model*

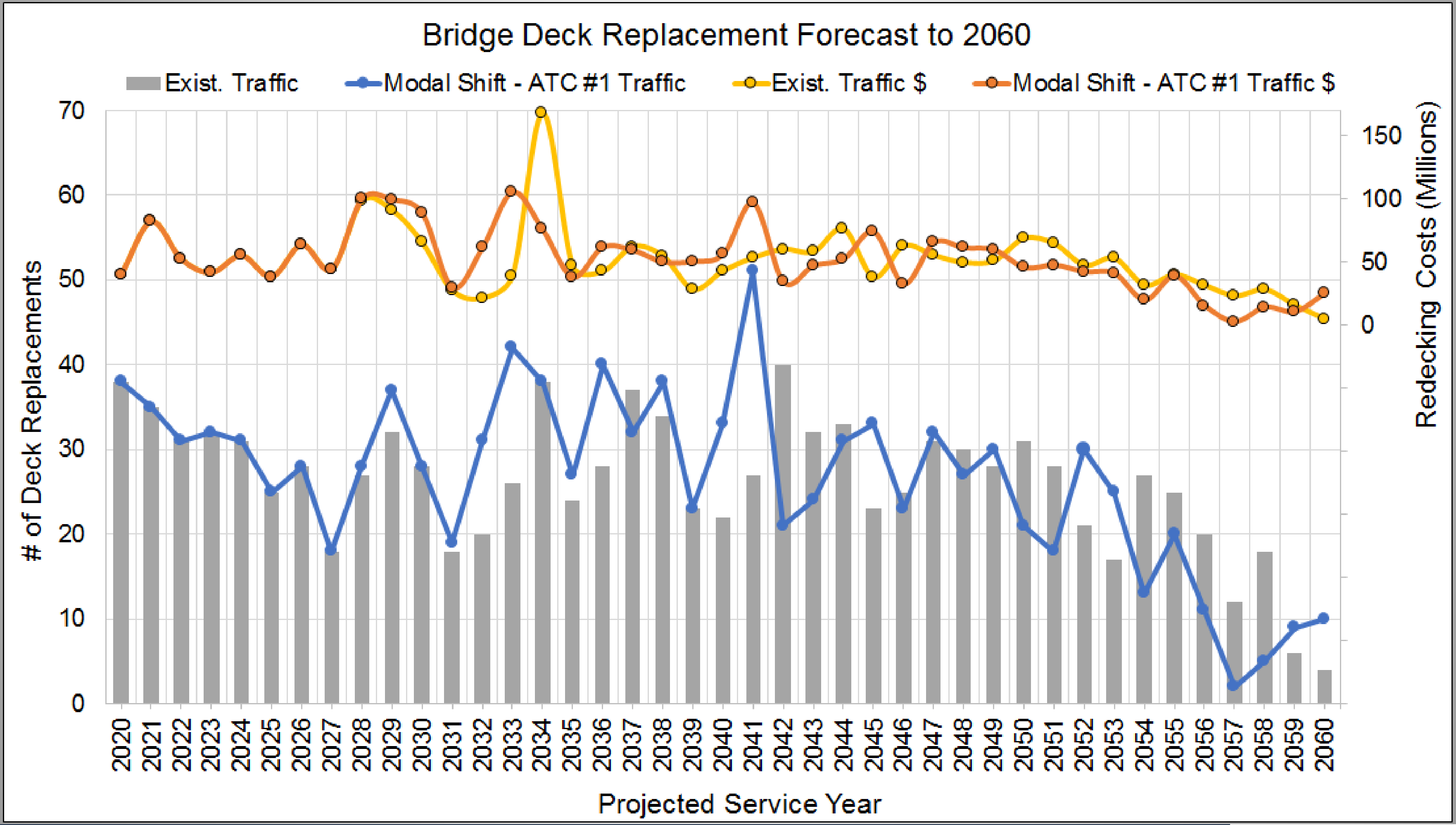
- TRB: doing something is better than nothing
- IDOT Study: Use historical deck replacement data

→Deck life prediction model using: ESAL, Longest Span, Latitude, and District

- Approx. 7,500 slab-beam type bridges in GIS → approx. 1,200 w/ significant MU data

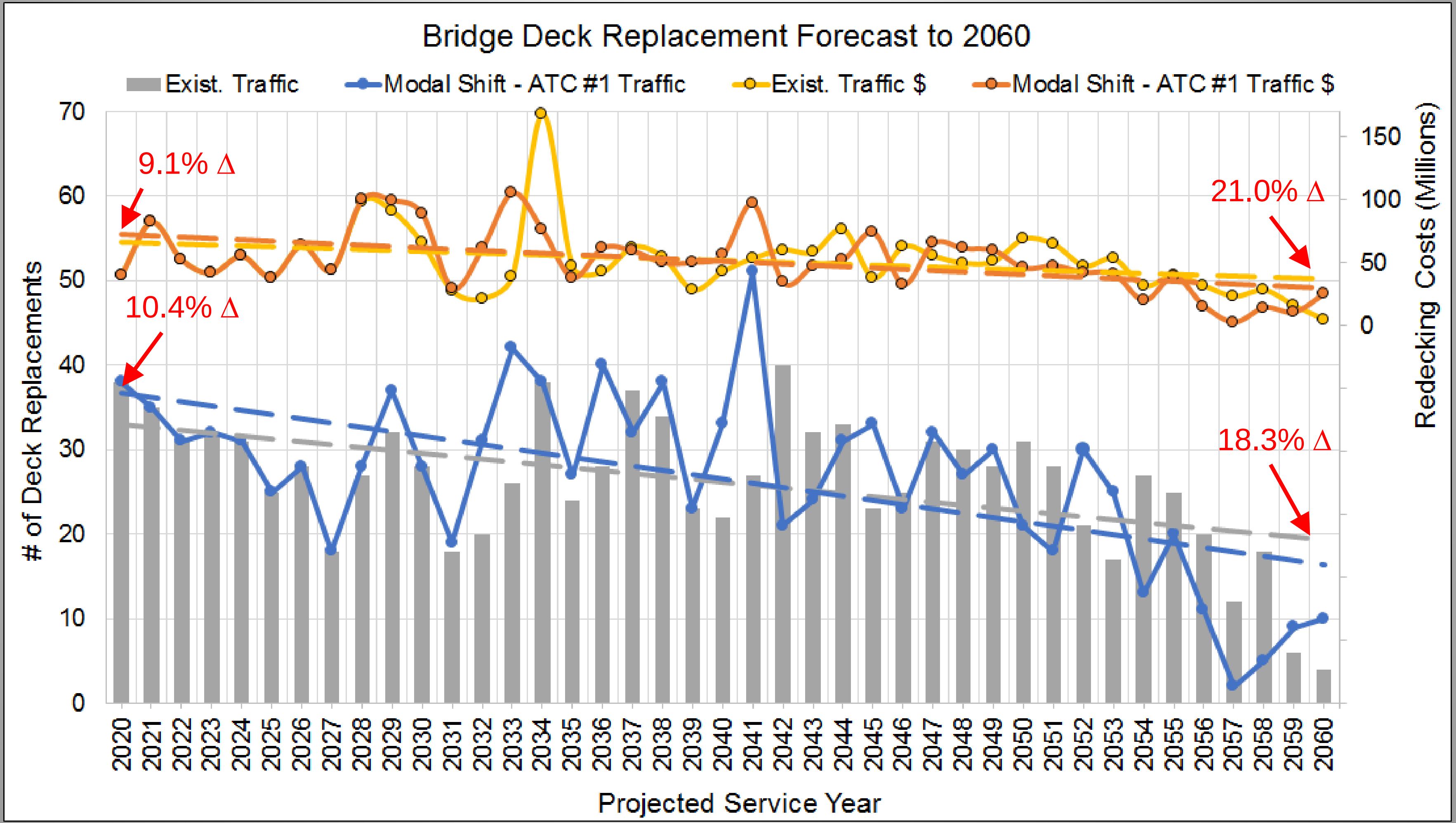
Structures

- ATC #1 prelim. results - 1,200 structures w/ sig. MU data



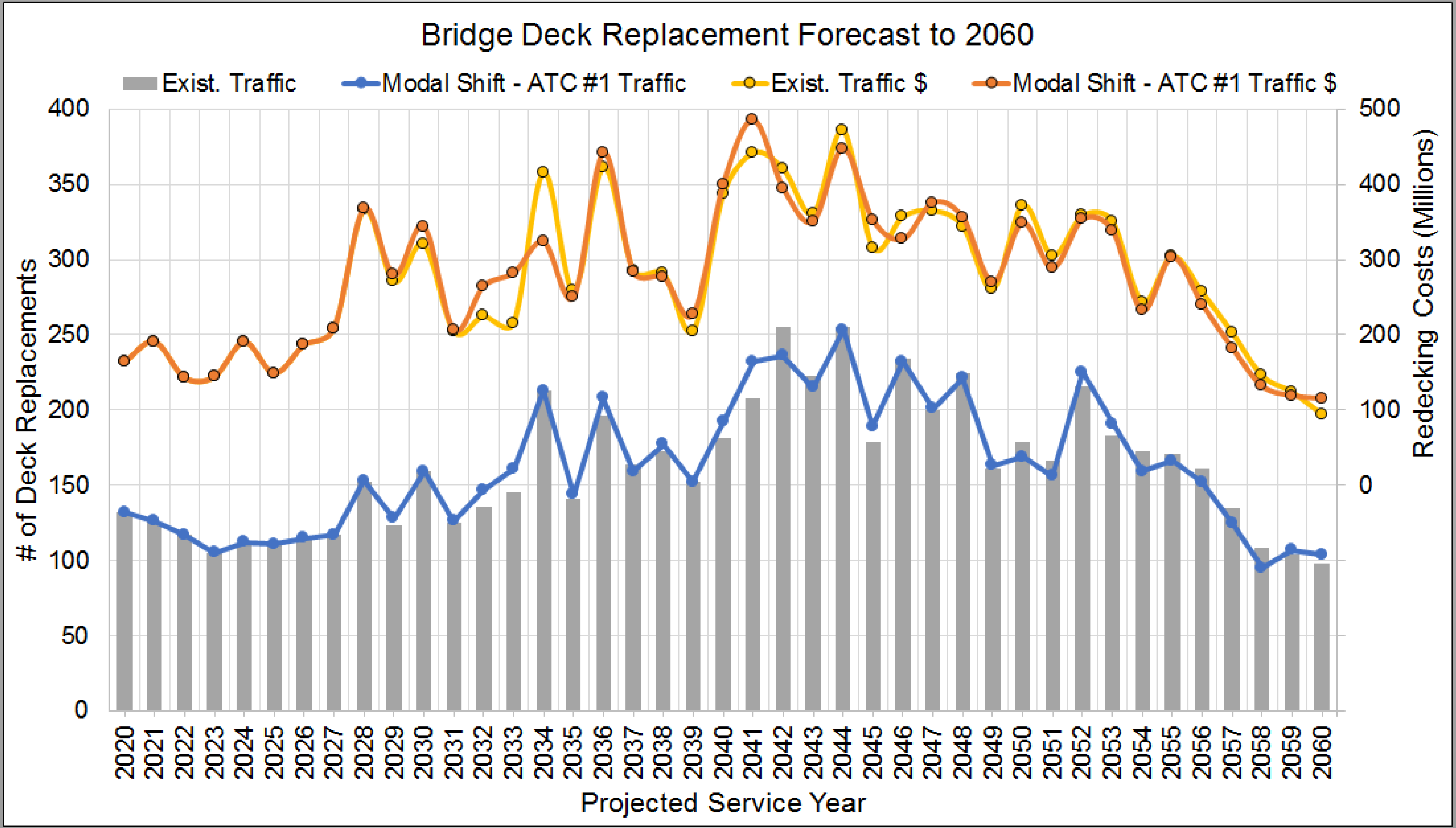
Structures

- ATC #1 prelim. results - 1,200 structures w/ sig. MU data



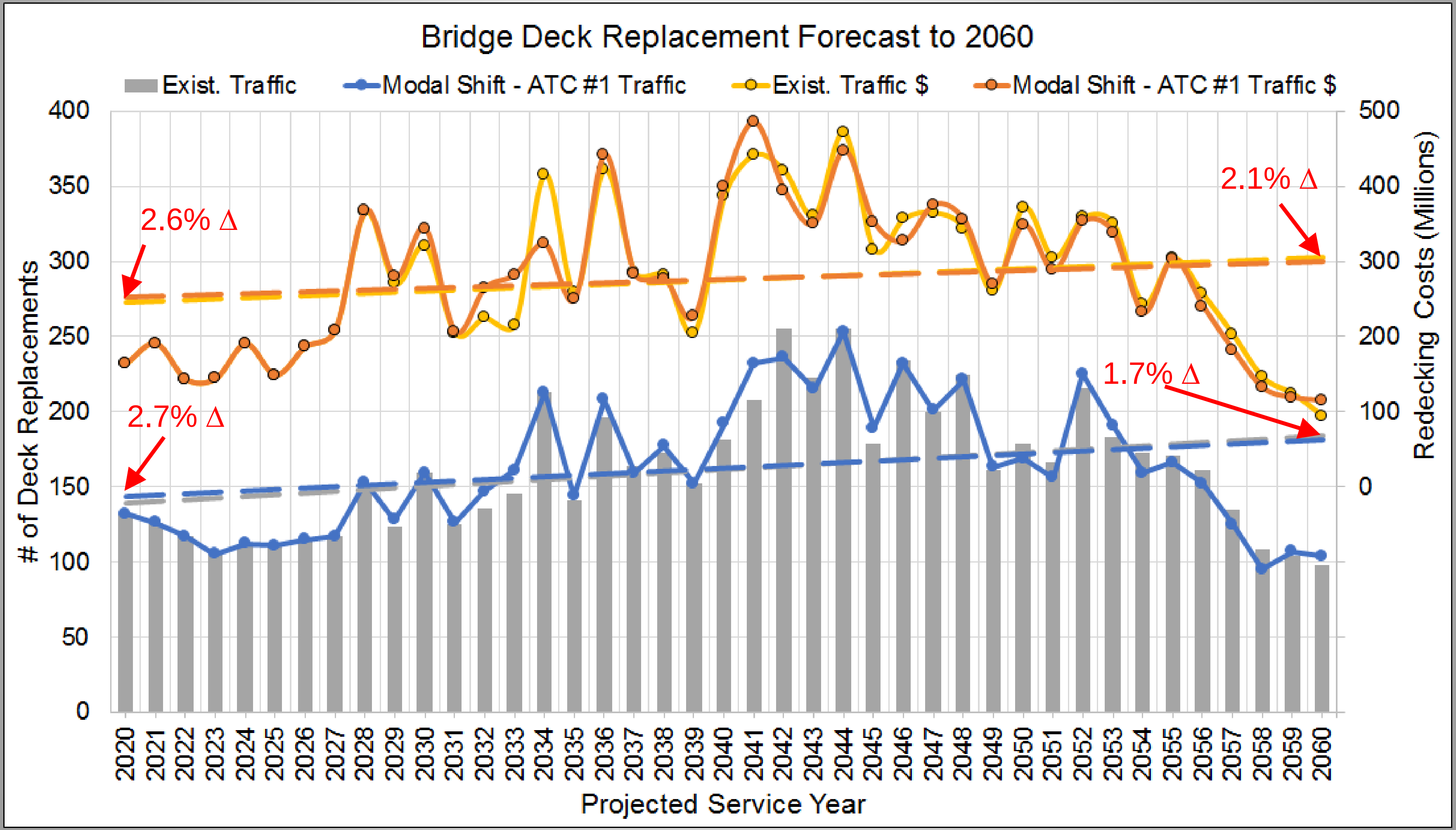
Structures

- ATC #1 prelim. results – 7,500 structures



Structures

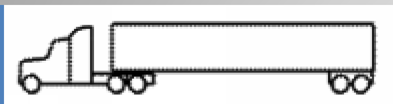
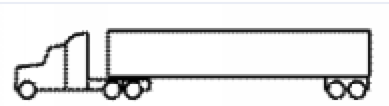
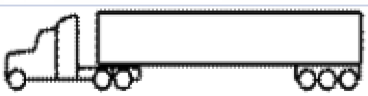
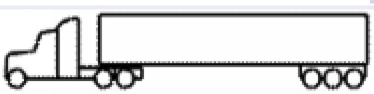
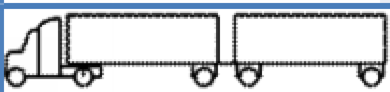
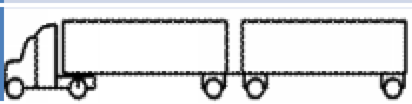
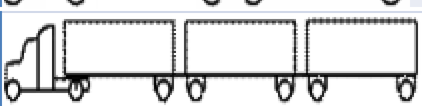
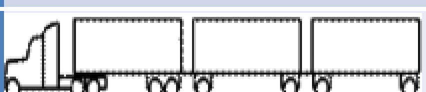
- ATC #1 prelim. results – 7,500 structures

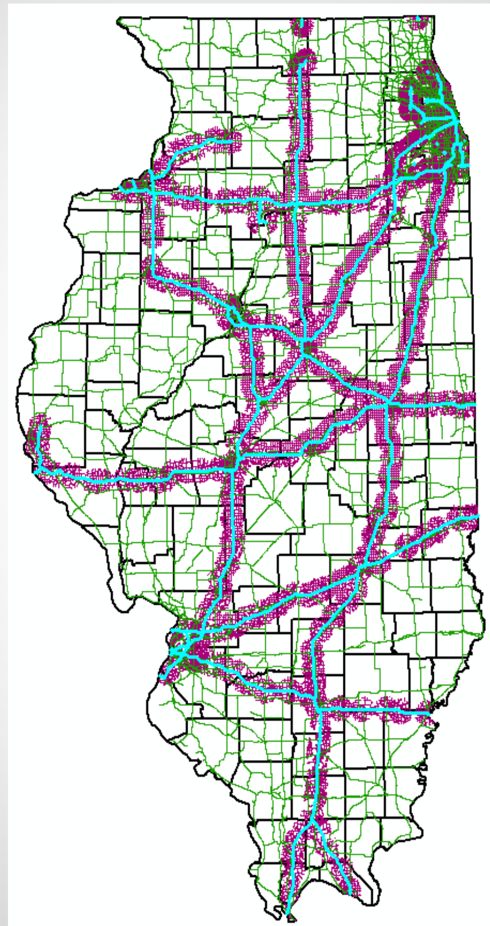


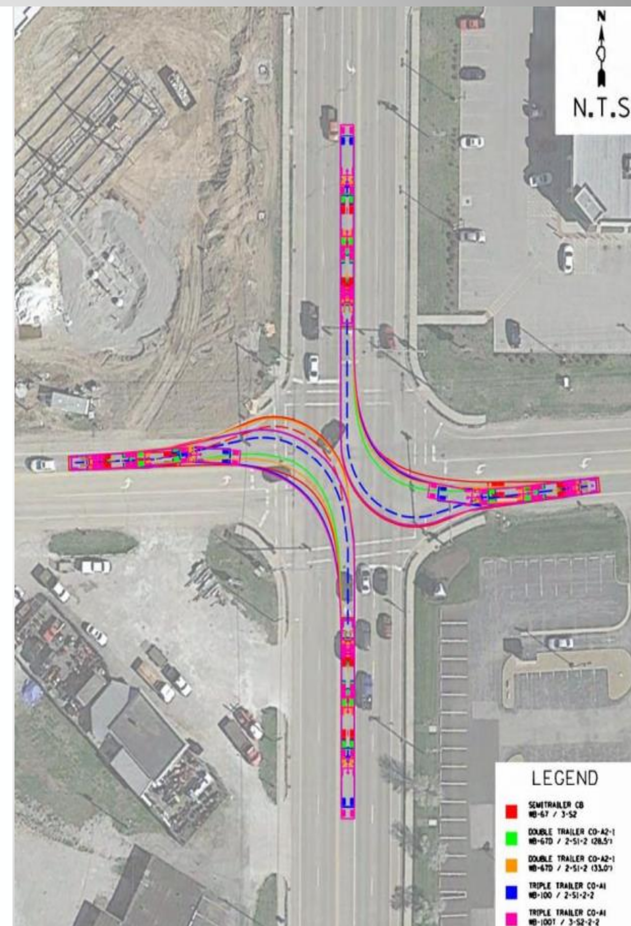
Ongoing Efforts

- Continuing state route/local road pav't analysis
- Analysis checking
- Assessing $$ impacts → including combining $$ impacts various ATC's
- Draft Report: present results and document our analysis procedure
- Final Report to IDOT anticipated end of 2019
- Logging data and results in GIS

Questions?

Control Single		80,000
1		88,000
2		91,000
3		97,000
Control Double		80,000
4		80,000
5		105,500
6		129,000





whks