

Forecasting State of Florida Safety Performance Measures

presented by

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2/27/2020



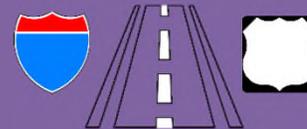
State of Florida



21.5 million
Population



126 million
Visitors/Tourists



12,000 miles
Highways

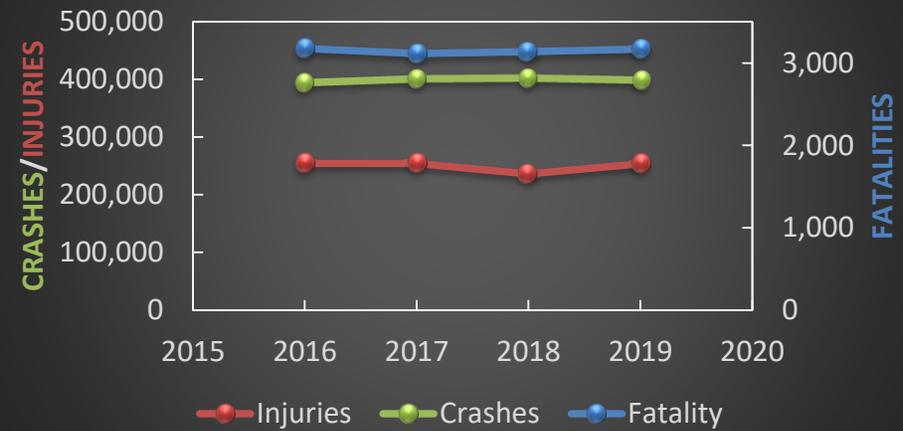


21.8 million
Registered Vehicles

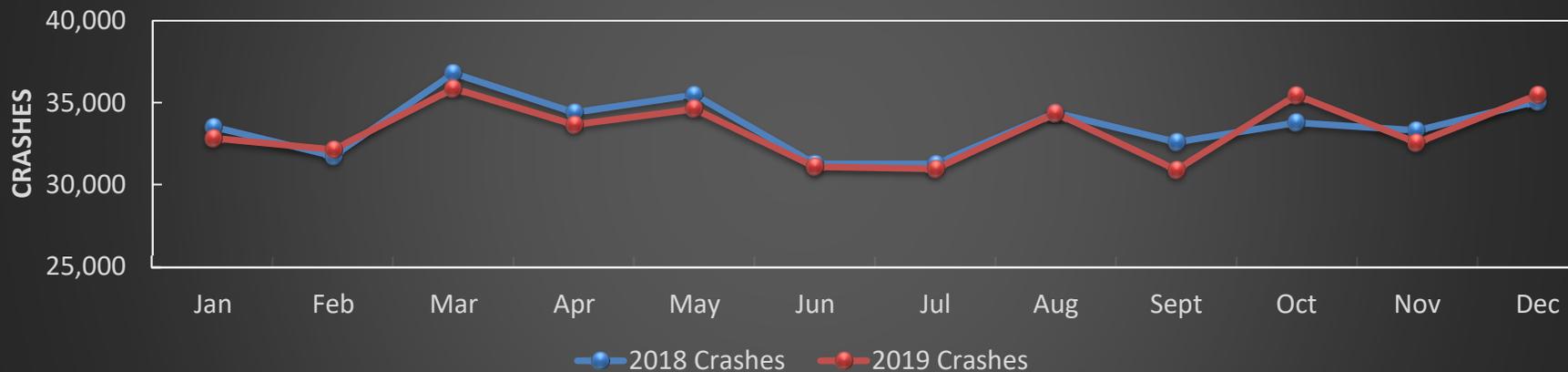
Florida Crash Facts



Florida Crash Statistics



Florida Crashes by Month



Performance Goals



MAP-21

Moving Ahead for Progress in the 21st Century Act

National Performance Goals (23 USC §150(b))

- **Safety**
- Infrastructure Condition
- Congestion Reduction
- System Reliability
- Freight Movement and Economic Vitality
- Environmental Sustainability
- Reduced Project Delivery Delays



Safety Measures



- Fatalities
- Fatality Rates (per 100 million VMT)



- Serious Injuries
- Serious Injury Rates (per 100 million VMT)



- Non-Motorized Fatalities and Serious Injuries



Additional Safety Measures



- Unrestrained Occupant Fatalities
- Driver or Motorcyclist with Blood Alcohol Concentration (BAC) ≥ 0.08



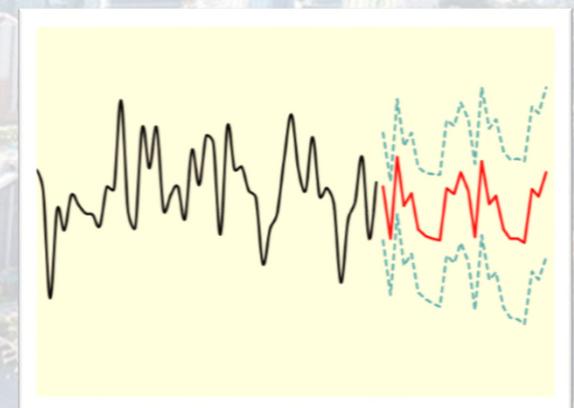
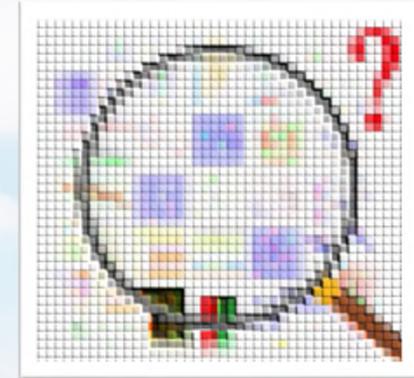
- Speeding Fatalities
- Motorcycle Fatalities
- Unhelmeted Motorcycle Fatalities
- Fatalities of Driver Age 20 Years Old or Less
- Pedestrian Fatalities
- Bicycle Fatalities



Forecast Approaches



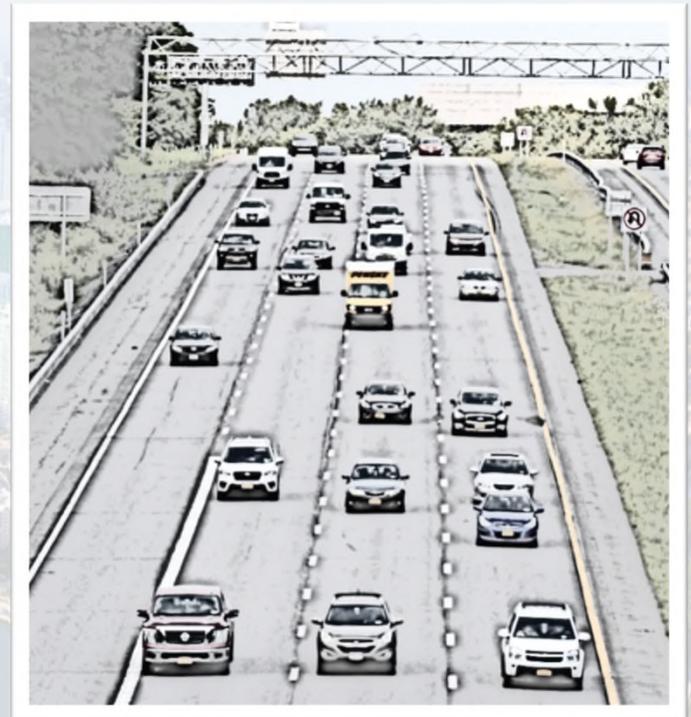
- **Exploratory Analysis**
 - Test a range of variables for correlation with fatalities and serious injuries
- **Statistic Model Selection**
 - Time Series ARIMA Model
- **Pre-Forecasts**
 - Hold back 2 years of actual data, forecast these 2 years based on previous years and compare with actual data
- **Forecasts**
 - Forecast 2 future years based on available data



Exploratory Analysis



- **Tested Linear Correlation for**
 - Vehicle Miles Traveled (VMT) ✓
 - Gas Consumption
 - Vehicle Registration
 - Florida Gross Domestic Product (GDP)
 - Florida Visitors
 - Temperature
 - Precipitation



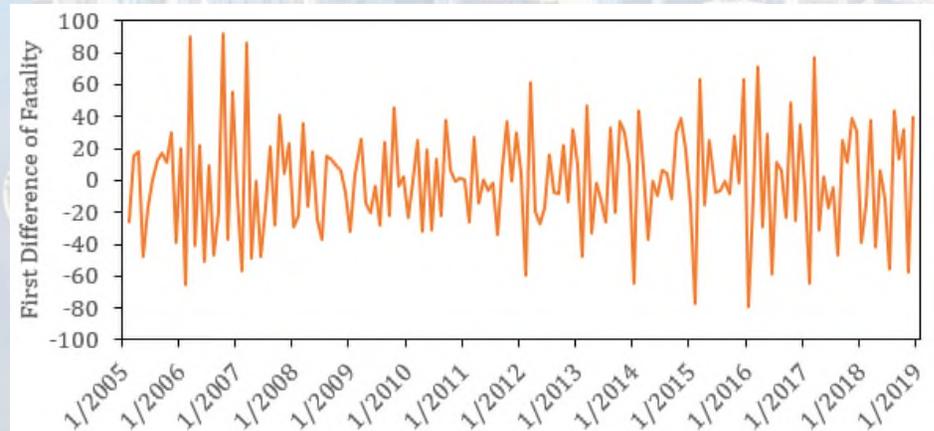
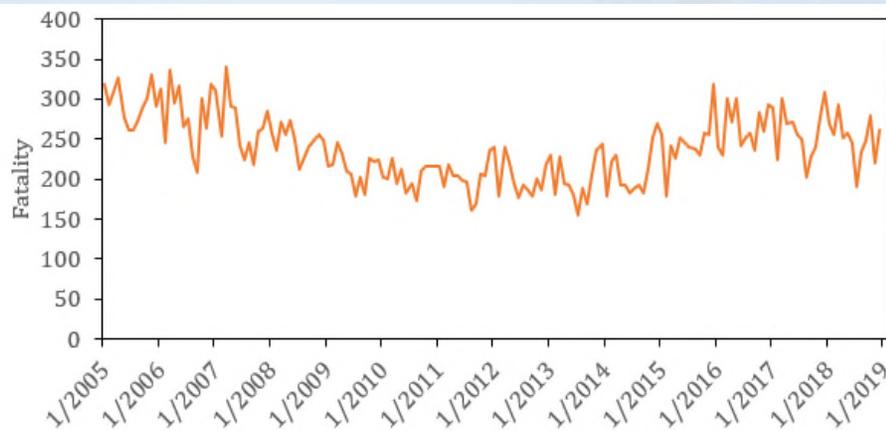
ARIMA Model



- **Time Series Model**
 - Forecast future based on past trends

Autoregressive-Integrated-Moving-Average (ARIMA) Model

- **Autoregressive:** regressed on its own lagged/prior values
- **Integrated:** fulfill the “Stationary” requirement
 - ❖ Mean and variance do not change over time
- **Moving Average:** regression errors occurred contemporaneously and at various times in the past



ARIMA Model



- **ARIMA Model**

- $ARIMA(p,d,q)(P,D,Q)_S$ with VMT regression

p – order of autoregressive
d – degree of differencing
q – order of moving average

Q – order of seasonal autoregressive
D – degree of seasonal differencing
Q – order of seasonal moving average
S – number of period in each season (12)

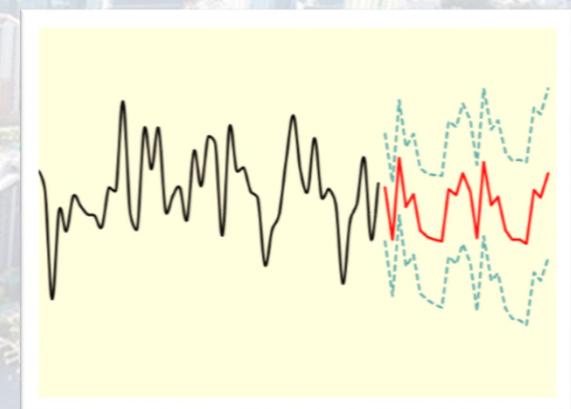
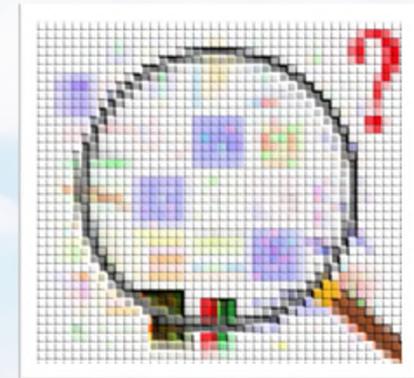
- **ARIMA Model Selection**

- Test multiple parameter values
- Select the model with **minimum** Akaike Information Criterion (AIC)

Forecast Approaches



- **Exploratory Analysis**
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 - Hold back 2 years of actual data, forecast these 2 years based on previous years and compare with actual data
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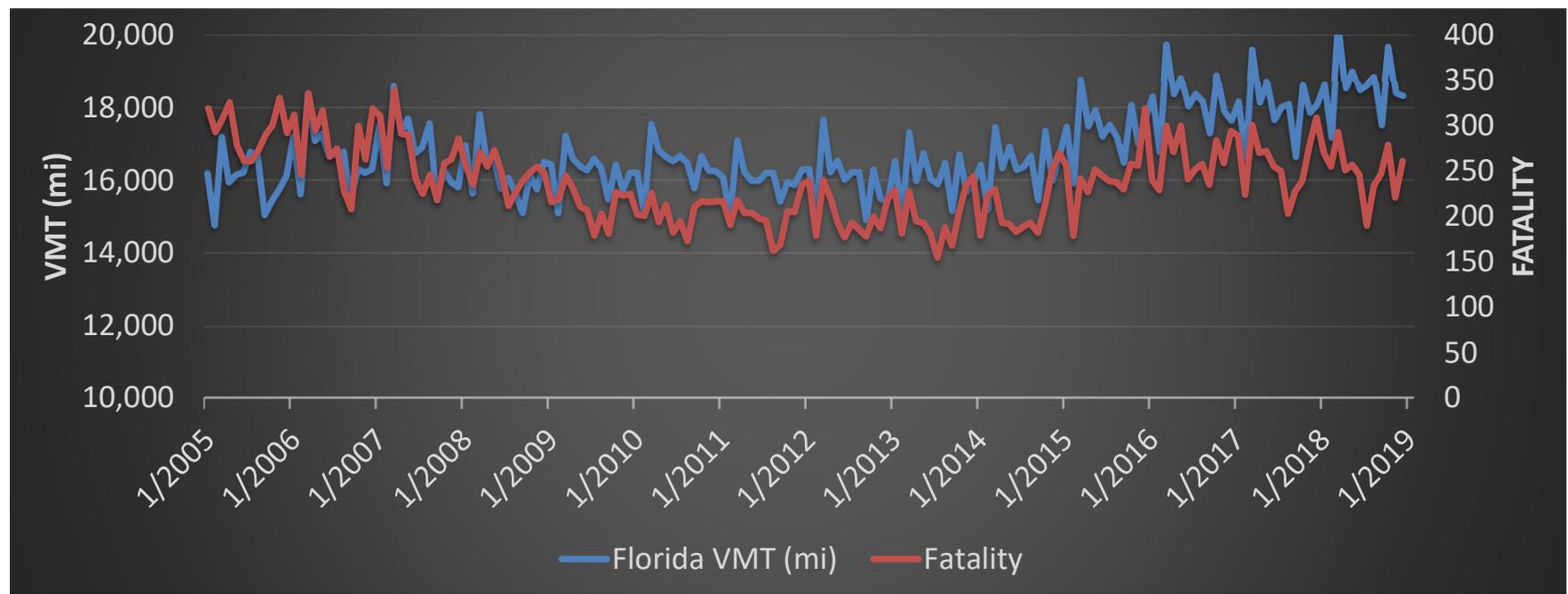
Fatality forecast as an example
based on 2005 to 2018 data

Example – Model Selection



- **Fatality**

- Based on 2005 January to 2018 December monthly data
- VMT data also available



Example – Model Selection



- **Fatality**
 - Based on 2005 January to 2018 December monthly data
 - Assume 0 seasonal differencing
 - $p, q, P,$ and Q range from 0, 1, 2

AIC												
D=0	P=0				P=1				P=2			
Q=0	d=1	p=0	p=1	p=2	d=1	p=0	p=1	p=2	d=1	p=0	p=1	p=2
	q=0	1,582	1,565	1,564	q=0	1,581	1,552	1,549	q=0	1,580	1,545	1,540
	q=1	1,557	1,544	1,545	q=1	1,529	1,528	1,528	q=1	1,521	1,522	1,522
	q=2	1,547	1,546	1,547	q=2	1,529	1,525	1,530	q=2	1,522	1,518	n/a
Q=1	d=1	p=0	p=1	p=2	d=1	p=0	p=1	p=2	d=1	p=0	p=1	p=2
	q=0	1,581	1,557	1,555	q=0	1,570	1,530	1,522	q=0	1,571	1,532	1,524
	q=1	1,540	1,535	1,536	q=1	1,503	n/a	1,507	q=1	1,505	1,512	1,509
	q=2	1,536	1,536	1,537	q=2	1,505	1,499	1,509	q=2	1,507	1,501	n/a
Q=2	d=1	p=0	p=1	p=2	d=1	p=0	p=1	p=2	d=1	p=0	p=1	p=2
	q=0	1,581	1,550	1,547	q=0	1,583	1,532	1,524	q=0	1,574	1,534	n/a
	q=1	1,530	1,528	1,528	q=1	1,505	1,507	1,509	q=1	1,507	n/a	n/a
	q=2	1,529	1,529	1,530	q=2	1,507	1,501	1,511	q=2	1,509	n/a	n/a

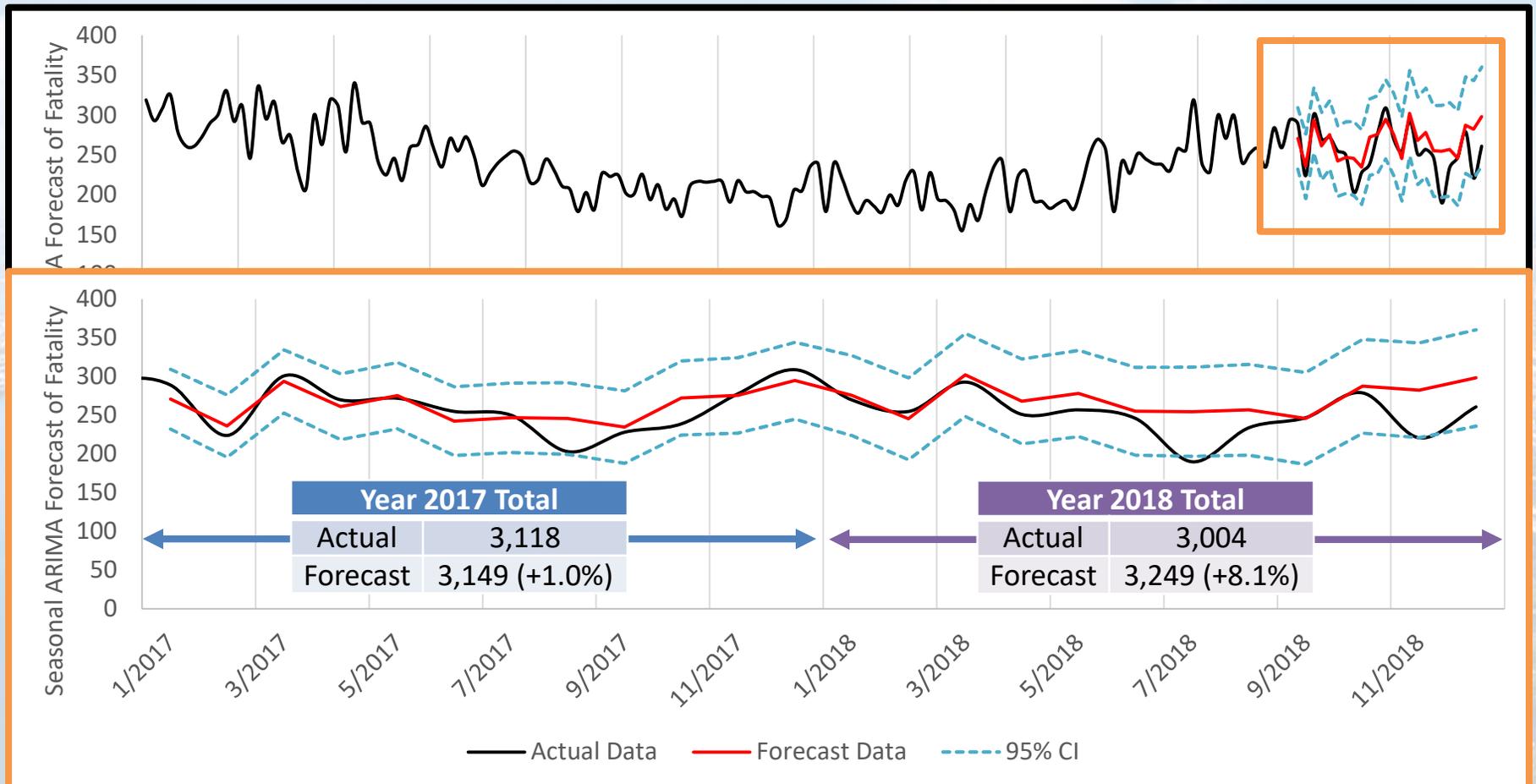
P-value < 0.01, indicating statistical significance for VMT regression

ARIMA (1,1,2)(1,0,1)₁₂ with VMT regression

Example – Pre-Forecasts



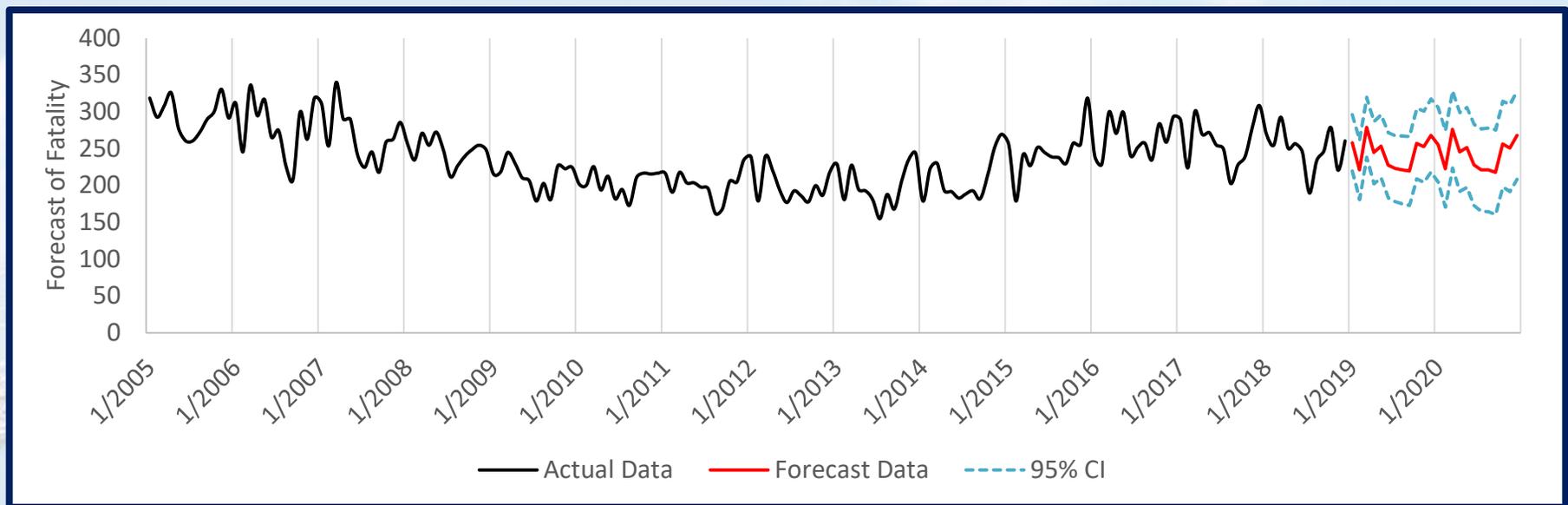
- Forecast 2017 and 2018 monthly fatalities with 95% Confidence Interval (CI) from 2005-2016 data
- Compare to actual 2017 and 2018 monthly fatalities



Example – Annual Forecasts



- Forecast 2019 and 2020 monthly fatalities with 95% Confidence Interval (CI) from 2005-2018 data

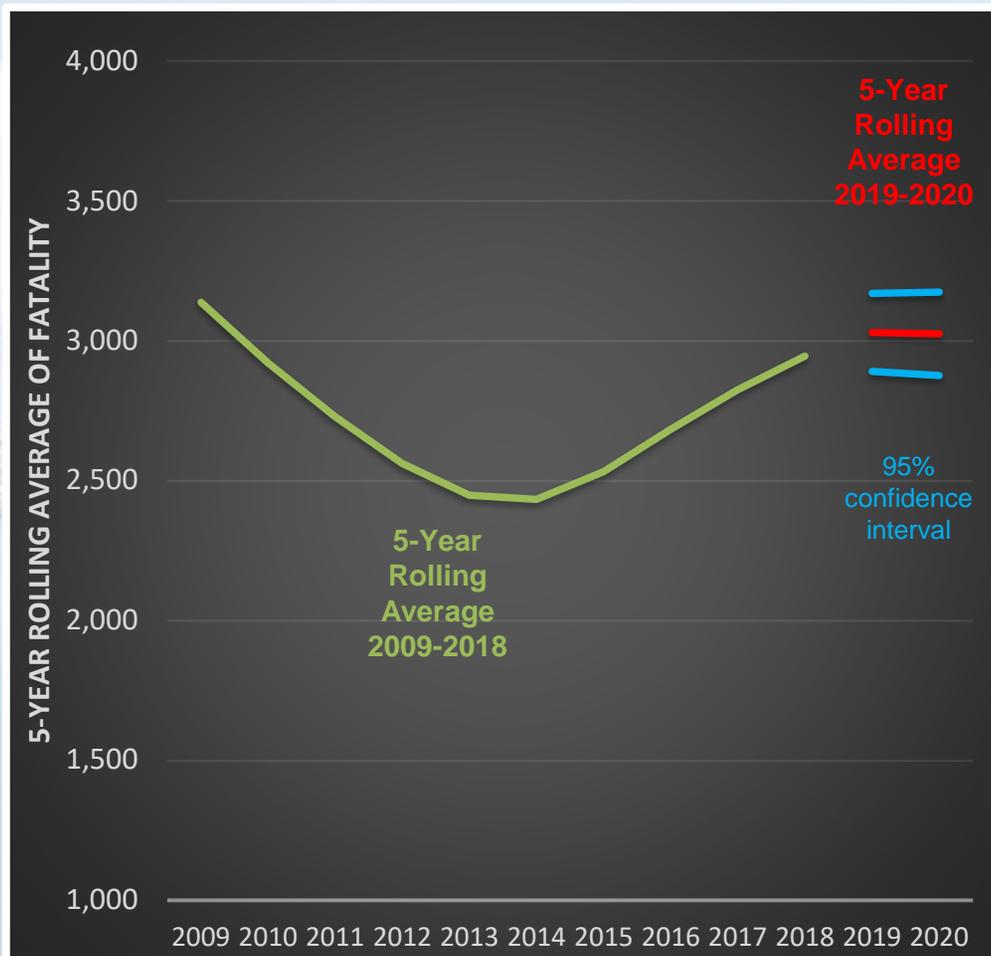


Year	Forecast of Fatality	95% Confidence Interval
2019	2,927	2,773 to 3,081
2020	2,916	2,724 to 3,109

Example – 5-Year Rolling Average Forecasts



- 2019 (5-year rolling average from 2015 to 2019)
- 2020 (5-year rolling average from 2016 to 2020)



Year	5-Year Rolling Average	
	Fatality	95% Confidence Interval
2020 (2016-20)	3,026	2,877 to 3,175
2019 (2015-19)	3,031	2,891 to 3,171
2018 (2014-18)	2,945	
2017 (2013-17)	2,824	
2016 (2012-16)	2,683	
2015 (2011-15)	2,532	
2014 (2010-14)	2,433	
2013 (2009-13)	2,447	
2012 (2008-12)	2,561	
2011 (2007-11)	2,723	
2010 (2006-10)	2,915	
2009 (2005-09)	3,132	

Model Selections



- **ARIMA model selected for each safety measure**
 - **Model may be slightly different based on available data**

Safety Measure		ARIMA Model Selected	
		ARIMA(p,d,q)(P,D,Q) ₁₂ with Regressor	
5 Safety Measures	Fatality	(1,1,2)(1,0,1)	VMT
	Fatality Rate	(1,1,2)(1,0,1)	n/a
	Serious Injury	(1,1,2)(2,0,1)	VMT
	Serious Injury Rate	(1,1,2)(1,0,2)	VMT
	Non-Motor Fatality & Serious Injury	(1,1,1)(1,0,1)	n/a
8 Additional Safety Measures	Unrestricted Occupant Fatality	(0,1,1)(1,0,1)	VMT
	Fatality of ≥0.08 BAC	(0,1,1)(1,0,1)	VMT
	Speeding Fatality	(0,1,1)(0,0,0)	VMT
	Motor Fatality	(0,1,1)(1,0,1)	VMT
	Unhelmeted Motor Fatality	(0,1,1)(1,0,2)	VMT
	Fatality of Age 20 or Less	(0,1,1)(0,0,1)	VMT
	Pedestrian Fatality	(0,1,1)(1,0,1)	n/a
	Bicycle Fatality	(1,1,1)(0,0,0)	n/a

Forecasts



- 5-year rolling average forecasts made for 2017, 2018, 2019, and 2020
 - 2017 and 2018 forecasts fall within **2.3%** of actual numbers
 - 2017 forecasts of fatality and fatality rate **match** actual numbers **EXACTLY**



Safety Measure	2017			2018			2019	2020
	Actual	Forecast	Difference	Actual	Forecast	Difference	Forecast	Forecast
Fatality	2,777	2,777	0.0%	2,945	2,876	-2.3%	3,031	3,026
Fatality Rate (per 100 million VMT)	1.34	1.34	0.0%	1.38	1.35	-2.2%	1.38	1.35
Serious Injury	20,605	20,320	-1.4%	20,476	20,529	0.3%	19,549	18,302
Serious Injury Rate (per 100 million VMT)	9.99	9.82	-1.7%	9.66	9.71	0.5%	8.94	8.13
Non-Motorized Fatality & Serious Injury	3,273	3,271	-0.1%	3,292	3,260	-1.0%	3,211	3,106

Forecasts



- 5-year rolling average forecasts made for 2017, 2018, 2019, and 2020
 - 2017 and 2018 forecasts fall within **28.1%** of actual numbers

Safety Measure	2017			2018			2019	2020
	Actual	Forecast	Difference	Actual	Forecast	Difference	Forecast	Forecast
Unrestricted Occupant Fatality	667	700	4.9%	728	656	-9.9%	719	714
Fatality of BAC \geq 0.08	355	374	5.4%	356	311	-12.6%	344	334
Speeding Fatality	281	260	-7.5%	249	266	6.8%	282	294
Motor Fatality	497	549	10.5%	472	524	11.0%	495	507
Unhelmeted Motor Fatality	228	292	28.1%	218	249	14.2%	243	245
Fatality of Age 20 or Less	375	399	6.4%	375	335	-10.7%	365	377
Pedestrian Fatality	616	646	4.9%	661	613	-7.3%	650	656
Bicycle Fatality	110	137	24.5%	141	133	-5.7%	135	141

Contact



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Thank you
Any Questions?

