Macro-Level Models for Quantitative Safety Planning

In Partnership with the Federal Highway Administration

Modeling Task Force Meeting

July 28, 2021

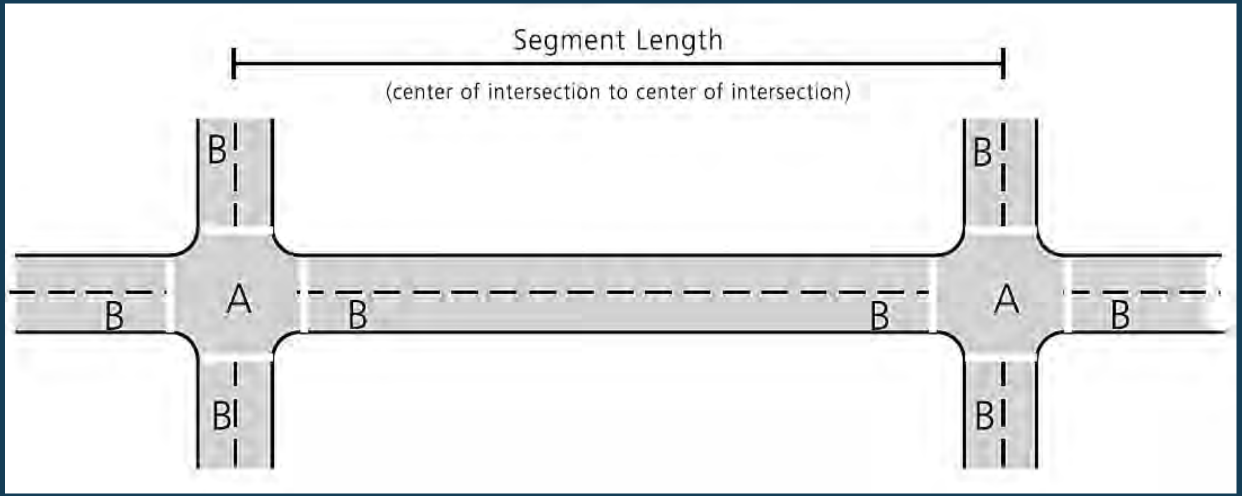
INNOVATING FOR A BETTER TOMORROW

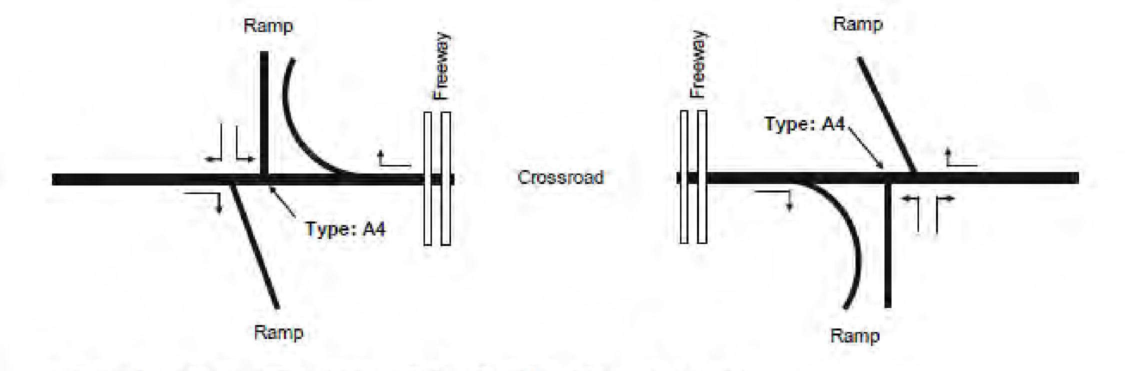
Background: Project Origins

- SCAG played a big role in NCHRP 17-81 agency outreach.
- Outreach helped inform the form and function of planning-level crash prediction models (CPMs).
- FHWA technical assistance to help implement the NCHRP 17-81 research at SCAG.

Background: Existing HSM Crash Prediction Models (CPMs)

- Fundamental analysis unit of the HSM processes, procedures, and methods is a “site” (e.g., a specific segment, intersection, ramp, or ramp terminal).
- An HSM user can combine analyses of multiple sites into a facility-level analysis (e.g., freeway facility with multiple interchanges).

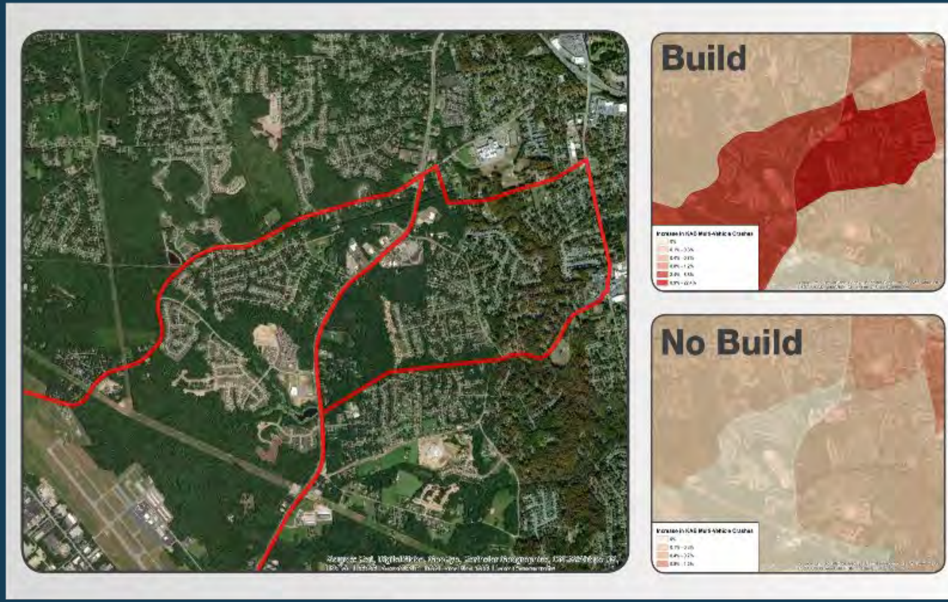




c. Four-Leg Ramp Terminal at Four-Quadrant Parclo A (*A4*)

Background: Macro-Level CPMs & NCHRP 17-81

- Predict average crash frequency, by crash type and severity, for a defined area, such as a census tract, traffic analysis zone, or county.
- Predictor variables for macro-level models characterize the broader area for which the models apply:
  - Area Type Classifications and Geography
  - Socioeconomics
  - Land Use
  - Presence/type/extent of Multimodal Transportation Infrastructure
- Intended to supplement the transportation planning process, not replace it (or create a whole new dimension).



2,400 new residents

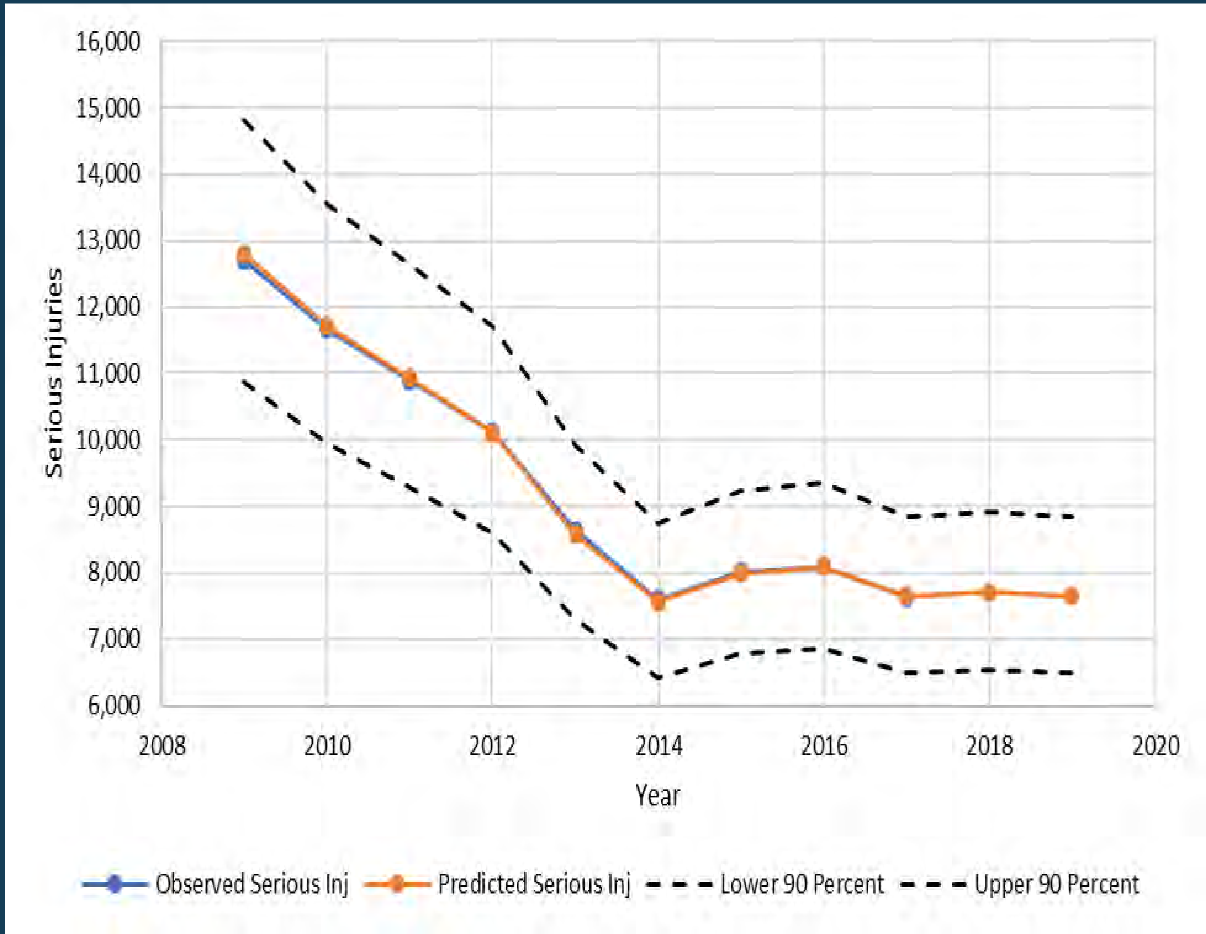
1,600 new employees

10% increase in highway traffic

8-20% estimated increase in KAB multi-vehicle crashes

Background: Potential Role of Macro-Level Crash Prediction Models

- Setting safety targets or performance measures (e.g., estimating #s of crashes in the future given population growth, land use changes, economy, & other related factors).
- Estimating how much investment in safety may be needed to meet future safety targets given growth and other changes.
- Assessing the safety impacts of large-scale projects.
- Comparing alternative growth scenarios (e.g., scenario planning).



Background: Project Overview

- FHWA Safety Data and Analysis Technical Assistance Program.
- Develop series of predictive models for safety planning and target setting.
- Safety Target Setting Models (3, county-level)
  - Fatalities
  - Serious injuries
  - Non-motorized fatalities and serious injuries
- Community Models
  - Predict traffic crashes at TAZ-level
  - Contributing to federal effort to produce macro-level crash prediction models & guidance for AASHTO Highway Safety Manual

Safety Target Setting Models

Background: Annual Safety Target Setting

- MAP-21 requirement
- Establish annual targets for:
  - Number of fatalities
  - Rate of fatalities per 100 million VMT
  - Number of serious injuries
  - Rate of serious injuries per 100 million VMT
  - Number of active transportation fatalities & serious injuries

Safety Target Setting Models - Data

- Natural events
  - Average precipitation
  - Fire coverage
- Vehicle miles traveled – annual estimates
  - By county
  - By functional classification (urban areas only)
- Demographic/Socioeconomic
  - Population
  - Employment
  - Age
  - Household income
  - Unemployment rate
  - Commuters by mode
- Project funding
  - Local Highway Safety Improvement Program (HSIP)
  - State Highway Operation and Protection Program (SHOPP)
- Behavioral indicators
  - Alcohol consumption – statewide by category

Safety Target Setting Models - Process

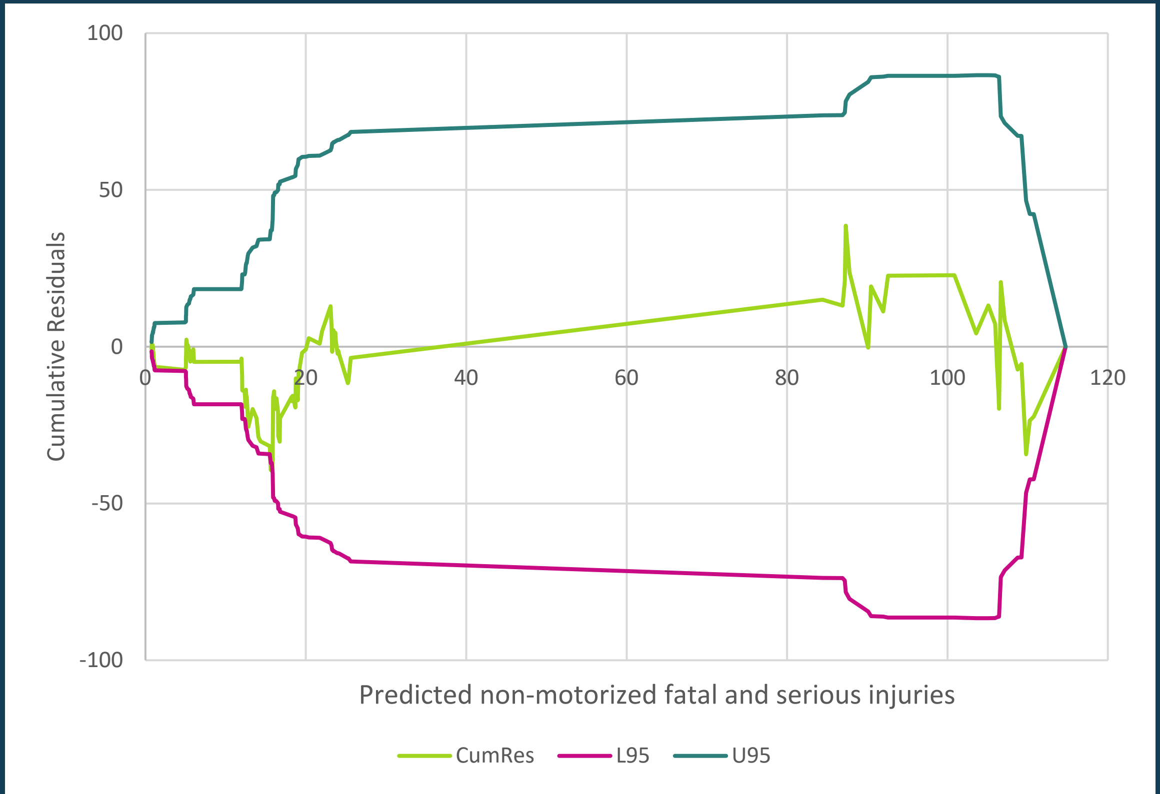
- Negative binomial regression.
  - County-Month as the unit of observation.
  - Common approach to safety modeling – lends itself to modeling over-dispersed count outcomes.
  - Lower threshold of statistical significance.
    - Avoid unobserved variable bias.

- Preliminary investigation of project-related effects.
  - Difficult to assess the influence of SHOPP funded projects; some potential for HSIP projects as an indicator.
  - Better data with respect to project location and construction dates.
  - Still weak relative to other variables.

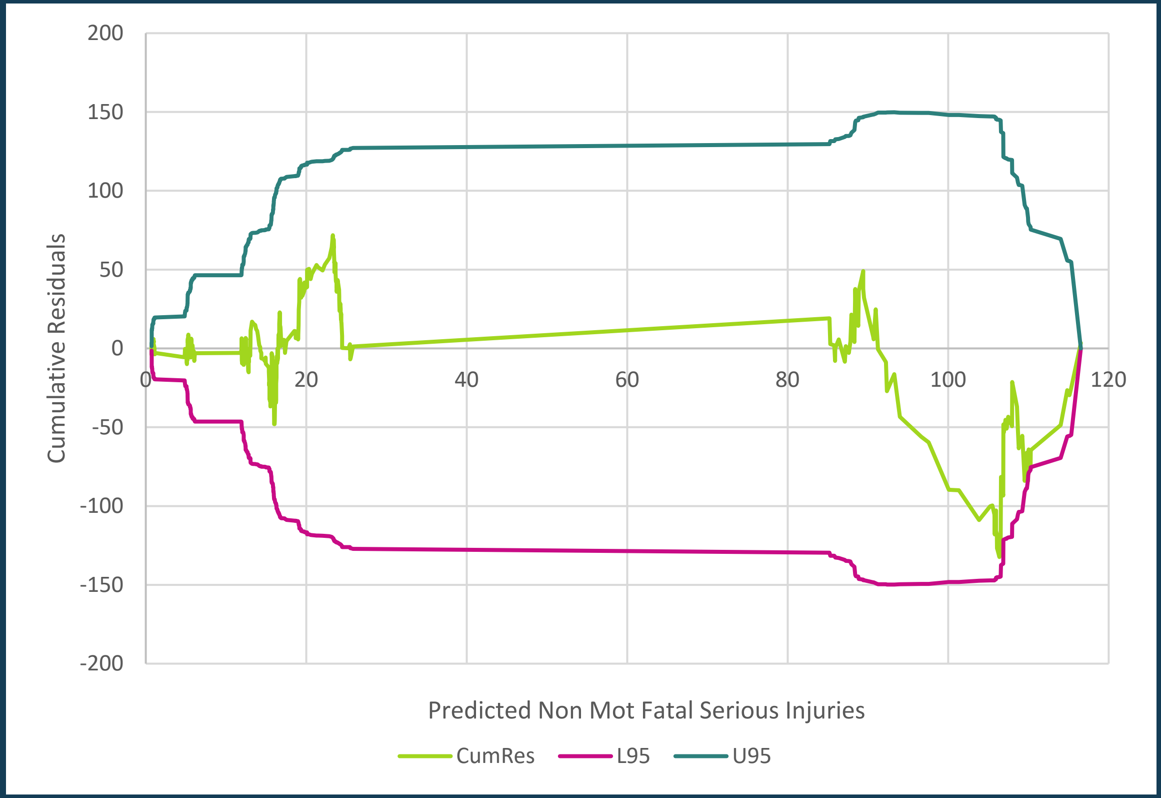
- Training and testing datasets used for model validation.
  - Model trained with 70% of data and tested on the remaining 30%.
  - Cumulative residual (CURE) plots used to assess model fit.

Safety Target Setting Models - Process

Testing Dataset

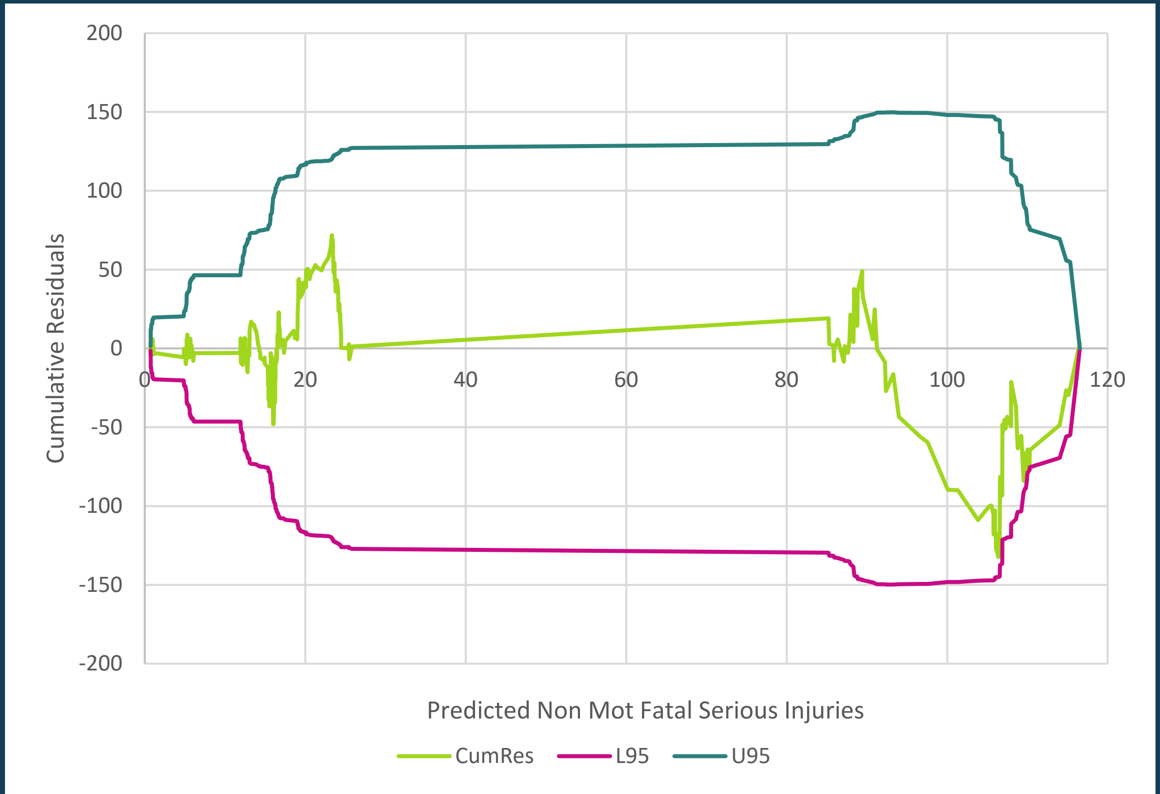


Full Dataset



Safety Target Setting Models - Process

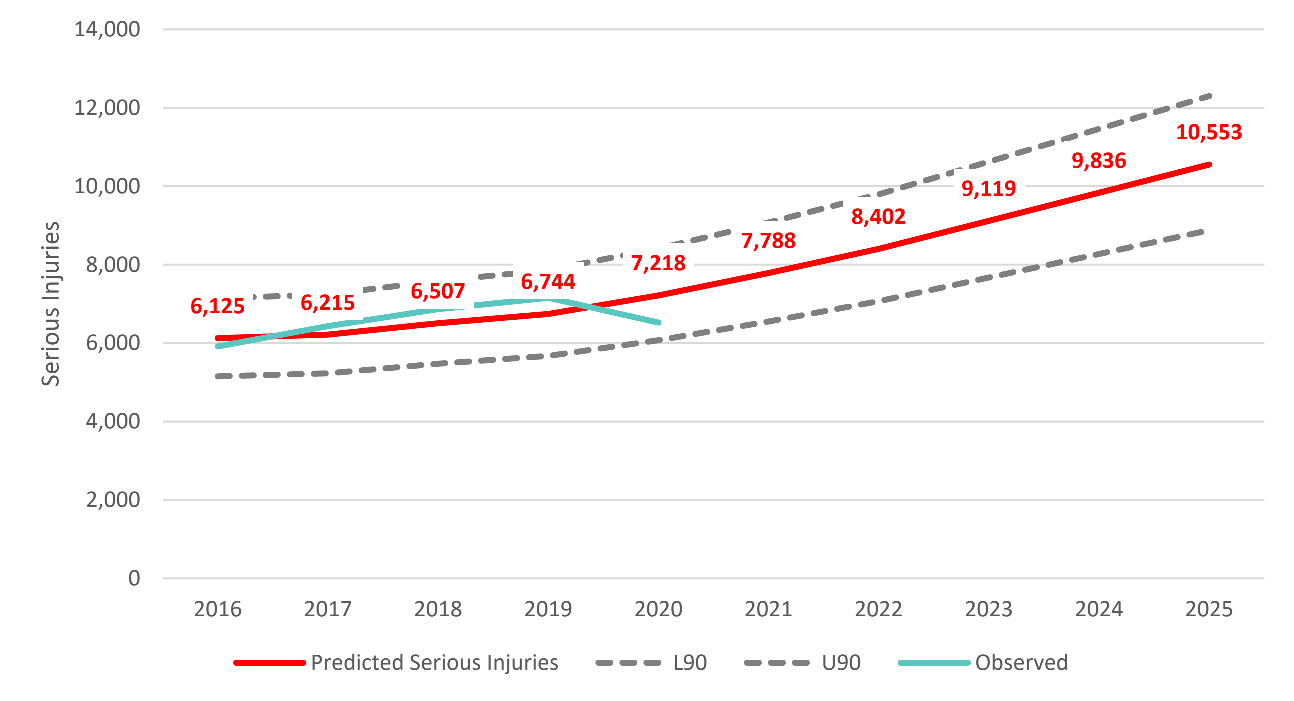
Data Input	Total Fatality Model	Total Serious Injury Model	Total Non-Motorized Fatality and Serious Injury Model
Annual VMT, Natural logarithm (LN)	✓	✓	
Proportion of VMT on urban interstates		✓	✓
Proportion of VMT on urban major collectors	✓	✓	
Proportion of VMT on urban local roads			✓
Proportion of population aged 65+		✓	
Proportion of population aged 15-24*	✓		
Proportion of population aged 18-24*		✓	
Median household income (2011$; divided by 1,000)	✓		✓
Total population			✓
Total employment			✓
Proportion of the population that commutes by transit, bicycle, or walks	✓		
Unemployment rate (Not seasonally adjusted)	✓		
Distilled spirit consumption per capita		✓	✓
Regular gas prices (2019$)			✓



Safety Target Setting Models - Results

- Highly intuitive results with strong connection to existing research.
- Identifies tangible safety indicators that could inform policy:
    - Traffic trends on facility types
    - Older and younger drivers
    - Alcohol consumption
    - Changes in employment and population trends

- These are baseline projections –can be affected by changed inputs. Possible to develop "what-if" scenarios – What could we expect?

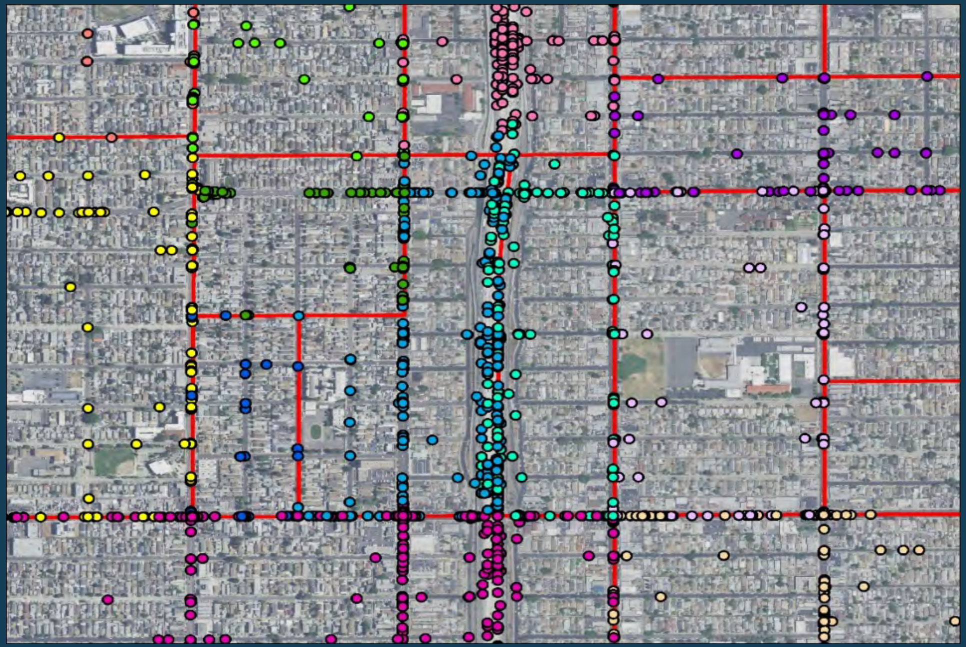


Community Models

Community Modeling - Data

- Data obtained and processed
  - TAZ boundaries
  - Crash location, type, and severity
  - VMT
  - Centerline mileage (including NHS)
  - Total population
  - Total employment
  - Median household income
  - Urban area
  - Transit stops
  - Intersections
  - Total commuting age population
    - Commute trips by mode

- Additional data
  - California Public Health Assessment Model
  - Disadvantaged Communities data



Community Modeling - Process

- Methods consistent with NCHRP 17-81.
  - Negative binomial regression.
  - Boundary data allocation – avoid duplication.
  - Outcomes compared with expectations based on NCHRP 17-81.

- CURE plots used to assess model fit.
  - No training/testing datasets – NCHRP research provides confidence that inputs are relevant.
  - Developing SCAG-specific models better than calibrating NCHRP models to SCAG's data (Census block group vs. TAZ).

Severity	Bicycle/ Pedestrian	Total Crash
K		All VMT (LN) (+) Median Household Income (divided by 1000) (-) Total intersections (+)
KA	All VMT (LN) (+) Median Household Income (divided by 1000) (-) Total Population + Employment (LN) (+) Transit stop density (+) Total walk, bike, and transit commuting proportion (+) 1/(1+TOT_AREA) (+)	All VMT (LN) (+) Median Household Income (divided by 1000) (-) Total intersections (+) 1/(1+TOT_AREA) (-)
KABC		All VMT (LN) (+) Median Household Income (divided by 1000) (-) Total intersections (+) 1/(1+TOT_AREA) (+)
KABCO	All VMT (LN) (+) Median Household Income (divided by 1000) (-) Total Population + Employment (LN) (+) Transit stop density (+) Total walk, bike, and transit commuting proportion (+) 1/(1+TOT_AREA) (+)	All VMT (LN) (+) Median Household Income (divided by 1000) (-) Total intersections (+) 1/(1+TOT_AREA) (+)

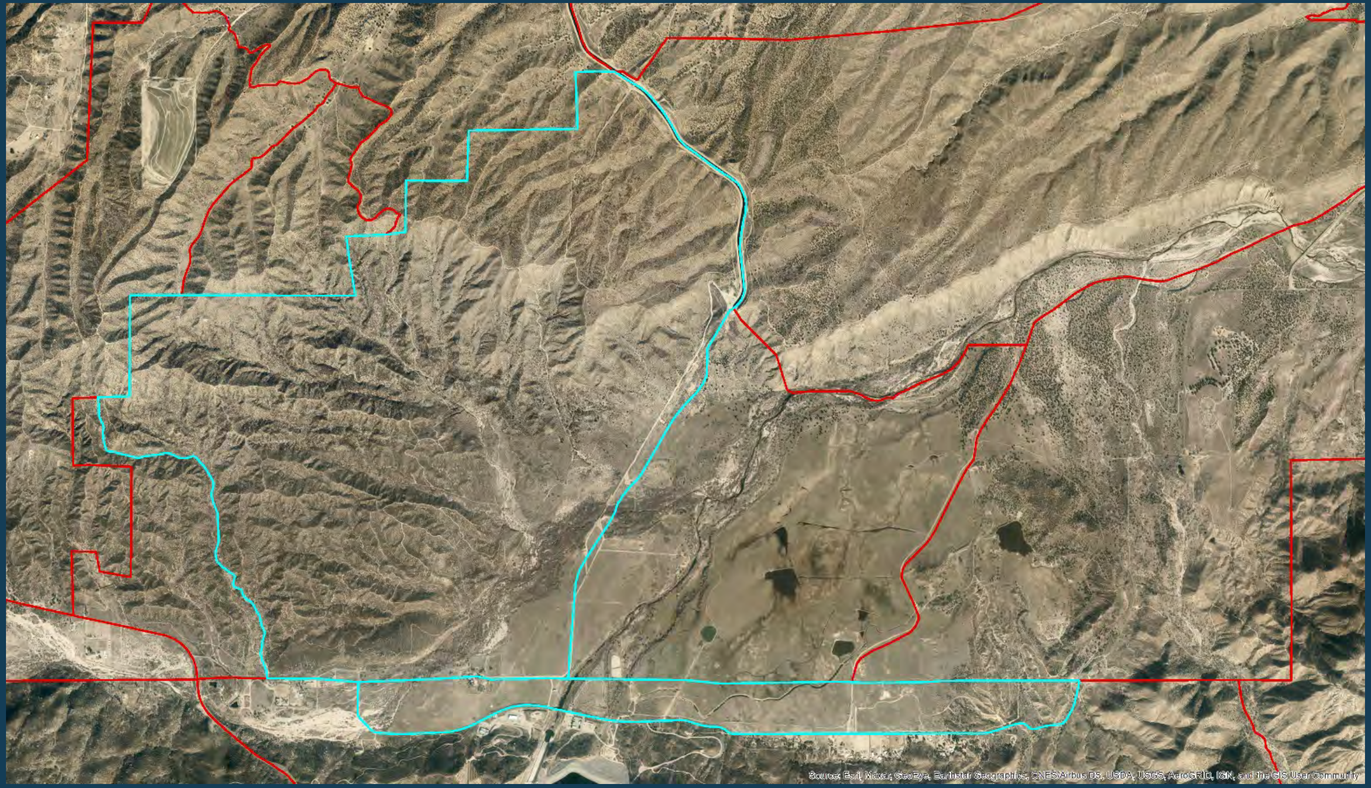
Community Modeling - Results

- Strong results highly consistent with the recent NCHRP research.
- Good model fit and predictive performance – limited over- and under-estimation while not overfitting the model.
- Inputs derived from SCAG's existing transportation models can support safety projections – complement the current planning process.

Data Input	Total Crash K	Total Crash KA	Total Crash KABC	Pedestrian/ Bicycle KA	Pedestrian/ Bicycle KABC
Annual VMT (LN)	✓	✓	✓	✓	✓
Median household income (2011$; divided by 1,000)	✓	✓	✓	✓	✓
Total population				✓	✓
Total employment		✓	✓	✓	✓
Commuting age population (aged 16 – 64)			✓		
TAZ boundaries (Inverse Area Variable)	✓	✓		✓	✓
Total intersections	✓	✓			
Total centerline mileage			✓		
Total NHS centerline mileage			✓		
Transit stop locations by mode				✓	✓

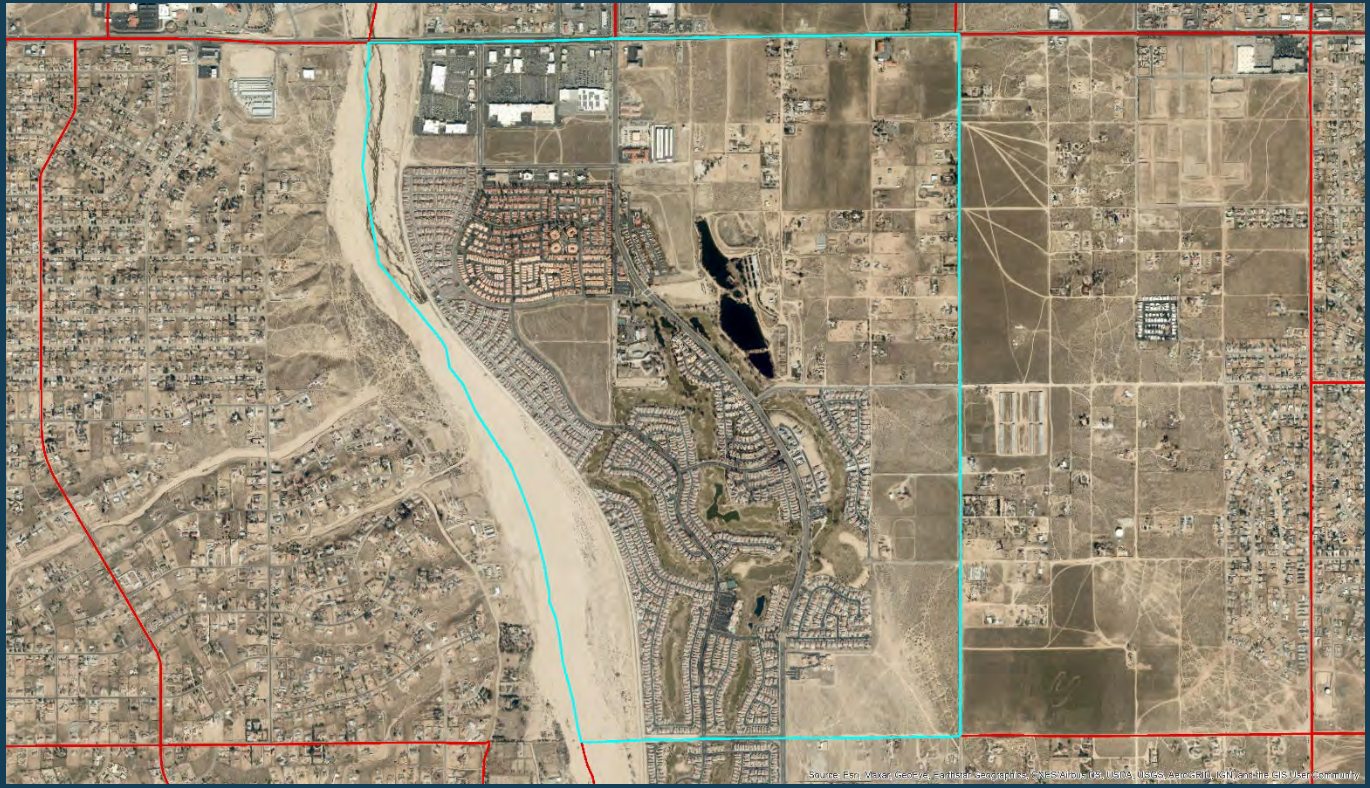
Community Modeling – Spatial Visualization & Examples

- 3 Sample Scenarios: What if by 2025?
- Significant increase in predicted pedestrian crashes (Hesperia, CA).
  - Population to more than double.
  - Associated increase in traffic.
  - Household income expected to decline.



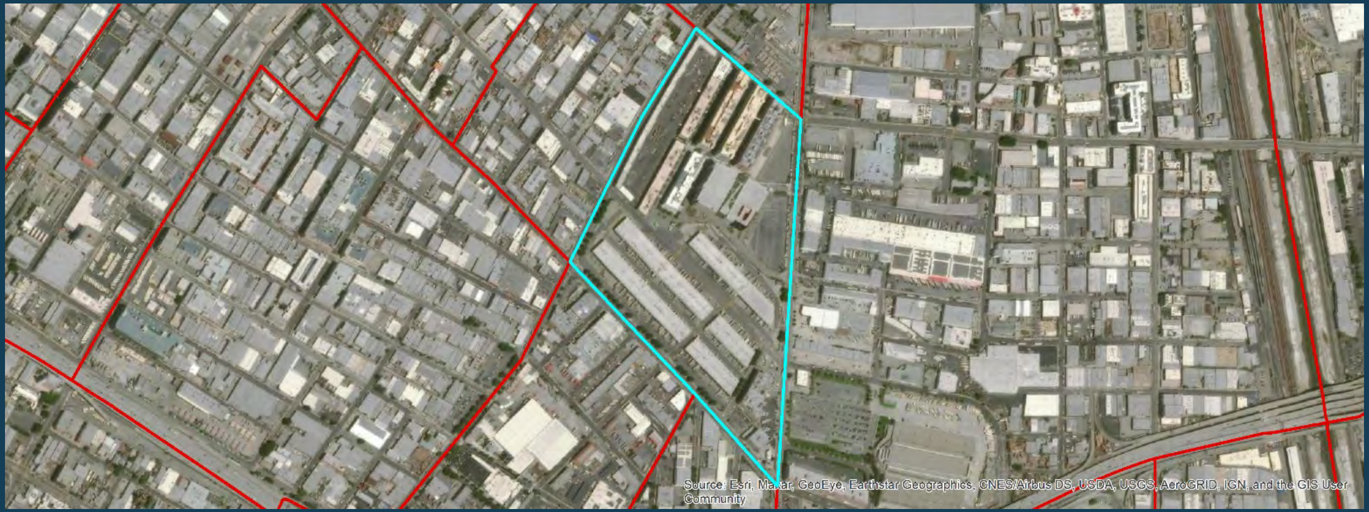
Community Modeling – Spatial Visualization & Examples

- 3 Sample Scenarios: What if by 2025?
- No major change in predicted pedestrian crashes (Hesperia, CA).
    - Population to slightly increase (~10%).
    - No change in employment.
    - Minor anticipated change in traffic volumes as a result.
    - Major increase in household income.



Community Modeling – Spatial Visualization & Examples

- 3 Sample Scenarios: What if by 2025?
- Decline in predicted fatal and serious injury crashes (Los Angeles, CA).
  - Very minor increase in population.
  - Notable decline in employment (greater than increase in population).
  - Potentially lower VMT.
  - Significant increase in median household income.



Future Considerations

- Models represent the baseline, business as usual path.
- Inputs can be adjusted or projected based on possible future outcomes.
- New information or changes to the transportation system can affect projections.
    - Local road safety initiatives
    - Increased investment and data-driven project programming
    - Speed management or implementation of a safe system approach
    - Improved vehicle safety features
    - Vehicle and infrastructure connectivity and other operational improvements
    - Development trends and personal travel choices
- Models are most effective when relative trends are used.
- Community models are most effective in places where people (will) live, work, and play.

Next Steps

- Share draft Technical Assistance Memo with stakeholders.
- Meet to discuss final work.
- Finalize technical assistance memo.
- Stakeholder feedback.
- Future phase: visualization tool – display scenario model results, interactive view of safety conditions within a community.

Questions? Comments?

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