Improve Sight Distance at Signalized Ramp Terminals of Partial Cloverleaf Interchanges to Deter Wrong-Way Entries

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Introduction

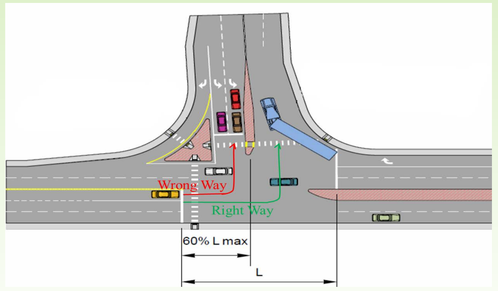
- Wrong-way driving (WWD) problem
  - It happens when a driver, drives against the main direction of flow.
- For partial cloverleaf (parclo) interchange terminals with close-spaced two-way ramps, appropriate intersection balance can provide motorists with a better view of entrance ramps and sight distance.
- A current best intersection balance practice by Washington State Department of Transportation (WSDOT) is to locate the stop line at no more than 60% of the way through the intersection.
- Median barriers, if extended too far, can block left-turn driver view of the entrance ramp terminal on the crossroad and increase the possibility of WWD.

Research Significance and Objective

- This WSDOT practice has not been proven for safety benefits based on scientific research.
- To provide a comprehensive evaluation of the impacts of intersection balance on wrong-way crashes and sight distance.
- To investigate effects of different lengths of the median barriers used to separate two-way ramps on driver sight distance.

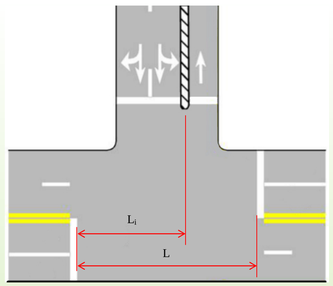
Data Collection

- Study Locations
  - Forty-four signalized ramp terminals of parclo interchanges in Illinois (IL).
  - The intersection balance was calculated: $S_i = L_i/L * 100$ (%)
- WWD Crashes
  - 2004-2013 crash data in IL from Highway Safety Information System (HSIS) of the FHWA.
  - Eighteen WWD crashes were collected at the study locations.
  - Twenty-one ramp terminals were identified as wrong-way entry points (one confirmed, ten first possible, eleven second possible, and one third possible).
  - Google Earth was a supplemental tool.

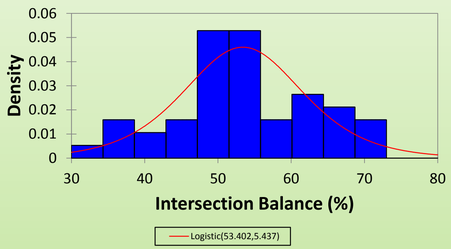


Intersection Balance at signalized ramp terminals of partial cloverleaf interchanges *(WSDOT 2013)*

Median barrier blocking driver view of the entrance ramp (*Google Map*)



Intersection balance



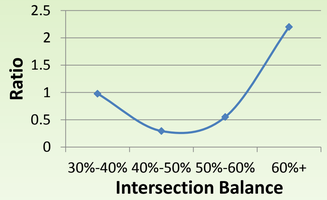
Frequency distribution of interchange terminals vs. intersection balance

Data Analysis and Results

- Frequency distribution and statistical analyses
  - Although there is no guideline in current MUTCD, the intersection balance of 50%-60% was frequently used at existing parclo interchange ramp terminals.
- Analysis of WWD crash data
  - Percentage of WWD crashes for each type of intersection balance: $P_c = n/N*100\%$
  - Percentage of interchange terminals where WWD crashes have occurred: $P_i = i/I*100\%$
  - Ratio: $R = P_c/P_i$
  - When the intersection balance is located ≥ 60%, the percentage of WWD crashes increased significantly.
  - Current practice from WSDOT was proven.
- Three-dimensional (3D) simulation & analytical method
  - To visualize driver view of the ramp terminal
  - Based on the perspective and simulation techniques from traditional architecture and landscape design
  - Considered human cognition to reveal the physical characteristics of roadway alignments
  - Worst-case scenario for drivers' sight distance, a passenger car
  - Driver's eye position: 25 cm (approximately 10 inches) above the center of the seat backrest denoted by a 3D cone
  - Driver's effective sight constrained by the car window frames denoted by a 3D rectangular plane
  - The percentage of right-way information in driver view increases as the median barrier length decreases and remains constant after a certain length is reached, with the intersection balance changing from 30%, 40%, 50%, to 60%.

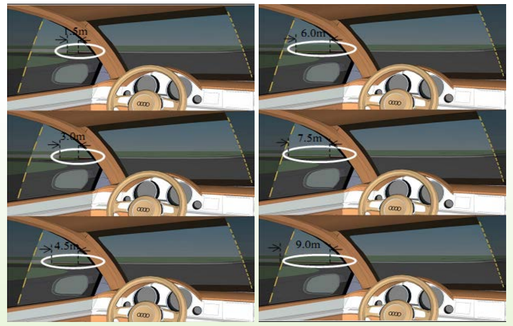
Conclusions

- The chance of WWD crashes increases significantly when the intersection balance is more than 60%.
- The effects of the median barrier length and intersection balance on drivers' sight distance were quantified.
- Guidelines can be developed for uniform median barrier lengths and intersection balance to improve sight distance.
- The 3D analytical methodology can be used to simulate driver view of roadway information.
- Future research can be conducted on other roadway features using this method.



Ratio of percentage of WWD crashes vs. percentage of interchange terminals

Illustration of driver view



Driver views with different intersection balances and median barrier lengths

Right-way Information vs. Median Barrier Length and Intersection Balance

Right-way information percentage		Distance from the median barrier ending point to the stop line on ramps							
		3.0m (9.84 ft.)	6.0m (19.69 ft.)	9.0m (29.53 ft.)	12.0m (39.37 ft.)	15.0m (49.21 ft.)	18.0m (59.06 ft.)	21.0m (68.90 ft.)	24.0m (78.74 ft.)
Inter-section Balance	30 %	1.41%	**1.69%**	**1.69%**	**1.69%**	**1.69%**	**1.69%**	**1.69%**	**1.69%**
	40 %	0.61%	0.90%	1.17%	**1.24%**	**1.24%**	**1.24%**	**1.24%**	**1.24%**
	50 %	0.57%	0.62%	0.76%	0.88%	0.97%	**1.03%**	**1.03%**	**1.03%**
	60 %	0.40%	0.50%	0.50%	0.56%	0.64%	0.70%	**0.75%**	**0.75%**