USING DETECTION-CONTROL SYSTEM (D-CS) TO IMPROVE SIGNALIZED INTERSECTION SAFETY

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Outline

- **Introduction**
  - Background
  - Indecision/dilemma zone
  - D-CS concept
  - Evaluations of D-CS

- **High-speed intersection environment**
  - Options for protecting decision zone
  - D-CS compared to other options

- **D-CS considerations**
  - Before/After test results
  - Site criteria for D-CS

- **Current D-CS deployment**
Introduction

- Background
  - Previous treatments for high-speed intersections
    - Green extension systems
      - TTI Truck Priority system
      - LHOVRA
    - Green termination systems
      - Self-optimizing signal (SOS) system
      - Detection-Control system
  - TxDOT Research Project “Detection-Control System for Rural High-Speed Intersections”
    - Original research: Sept 1, 2000 - Aug 31, 2002
    - Safety and operational considerations
Introduction

- Indecision/dilemma zone
  - Defined as travel time to stop line (e.g., 2.5-5.5 s)
  - $D_{bz}$: Begin zone-90% of drivers stop & 10% proceed
  - $D_{ez}$: End zone-90% of drivers go & 10% stop
  - Trucks vs. non-trucks
    - 2.5-5.5 s non-trucks
    - 2.5-7.5 s trucks

$D_{bz}$ = distance to the beginning of the dilemma zone
$D_{ez}$ = distance to the end of the dilemma zone
Introduction

- **D-CS Concept**
  - Overcomes multi-point detection limitations
  - Intelligently forecasts best-time-to-end green
    - Vehicle arrival in DZ
    - Speed/type vehicle
    - Conflicting delay
  - Safety objective
    - Reduce crashes
  - Operational objective
    - Minimize delay
Introduction

- Evaluations of D-CS
  - TxDOT – eight sites in Texas
    - Red-light runners
    - Delays/stops
    - Crash history
  - FHWA – eight sites in four states
    - Red-light runners
    - Vehicles in indecision zone
    - Phase max-outs
    - Crash history
High-Speed Intersection Environment

- Options for protecting indecision zone
  - Single advance detectors
  - Multiple advance detectors
    - Inductive loops
    - Magnetometers
    - Other point detectors
  - Non-intrusive detectors
    - Wavetronix SmartSensor Advance
    - Hybrid detectors by Iteris and FLIR
  - Detection-Control System
High-Speed Intersection Environment

- Multiple advance detectors
  - Advantages
    - Well known concept and components
  - Disadvantages
    - Loop failure rates may be high
    - Potential damage from roadside work
    - Exposure to traffic
    - Might not find adequate gap in high demand situations
    - No special consideration for trucks
High-Speed Intersection Environment

- Wavetronix Advance (SS-200)
  - Advantages
    - Non-intrusive
    - Simple setup
    - Tracks vehicles in real time
    - Adapts to variations in vehicle speeds
  - Disadvantages
    - Requires bucket truck to install
    - No left- or right-turn detection
    - Does not detect vehicles by lane
    - SS-200 max range is 600 ft from detector
    - Does not distinguish trucks (although SS200E does)
High-Speed Intersection Environment

- Detection-Control System
  - Advantages
    - Distinguishes trucks
    - Lane-by-lane detection
    - Adapts to variations in vehicle speeds
    - Considers minor movements directly
    - Forecasts best time to end phase
  - Disadvantages
    - Uses inductive loops (although others could be used)
    - Cost of trenching and wiring
    - Point detection (not continuous)
    - Requires lane closures for installation
## Comparison of Wavetronix Advance with D-CS

<table>
<thead>
<tr>
<th>Wavetronix Advance</th>
<th>Detection-Control System</th>
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<tbody>
<tr>
<td>Non-intrusive</td>
<td>Intrusive (loops, magnetometers)</td>
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<tr>
<td>Tracking (real-time)</td>
<td>Point detection</td>
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<tr>
<td>Area detection</td>
<td>Detection by lane</td>
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<tr>
<td>Classifies 80% of trucks</td>
<td>Classifies 95% of trucks</td>
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<tr>
<td>Requires bucket truck</td>
<td>Requires lane closure</td>
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<tr>
<td>Considers side-street delay indirectly</td>
<td>Considers side-street delay directly</td>
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<td>Uncertain of accuracy in high volume</td>
<td>Works well in high speed, high volume</td>
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<td>Uncertain of readiness for Conn. Veh.</td>
<td>Connected Vehicle potential</td>
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<td>Intersection cost: $16,090</td>
<td>Intersection cost: $28,450 to $51,312</td>
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</tbody>
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**Notes:**
- Non-intrusive: Does not require physical changes to the road.
- Tracking (real-time): Monitors vehicles in real-time.
- Area detection: Monitors large areas for traffic.
- Classifies 80% of trucks: Identifies 80% of trucks on the road.
- Considers side-street delay indirectly: Accounts for delays on side streets indirectly.
- Intersection cost: $16,090 to $51,312: Range of intersection installation costs.
D-CS Impacts—TxDOT Findings

- Red-light violations (10 approaches)
  - All vehicles: 58% reduction overall
  - Heavy vehicles: 80% reduction overall

- Operational measures
  - Overall changes (10 approaches)
    - Reduction in total control delay: -14%
    - Reduction in total vehicles stopping: -9%

- Crashes
  - Overall changes (5 intersections)
    - All vehicles: 39% reduction
    - Overall range from -6% to -64%
D-CS Impacts—FHWA Findings

- Red-light violations (16 approaches)
  - All vehicles: 82% reduction
  - Heavy vehicles not evaluated separately
- Operational measures
  - Max-outs reduced by 63%
  - Vehicles caught in indecision zone reduced by 73%
- Crashes
  - Angle and rear-end crashes
    - Overall reduction 9%
    - Limited sample size
Site Criteria for D-CS

- Isolated full-actuated intersections
- Intersection of major road & minor road
- 85\textsuperscript{th} percentile speed (or speed limit) > 45 mph
- Total turn percentage (right plus left) < 40%
- Truck traffic > 10\% (off-peak) or > 5\% (peak)
- Crash rates (rear-end & right angle) > similar local intersections
Current D-CS Deployment Project

- Objectives
  - Improve safety at rural high speed signalized intersections
  - Make D-CS technology available from other signal controller manufacturers
  - Develop marketing and training materials in support of D-CS deployment
Current D-CS Deployment Project

- Prioritize Signal Controller Platforms for D-CS Implementation
- Develop Design Specifications
- Develop Verification Plan
- Develop Marketing and Training Material
- Coordinate D-CS Implementation Work
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