SAFETY EFFECTS OF SKEWED INTERSECTIONS

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INTRODUCTION

- FIELD OF VISION
- MOBILITY
- VISION OBSTRUCTION
- DRIVERS’ LATERAL VISION
- A VEHICLE MAY BE LOCATED IN THE BLIND SPOT

- HUMAN FACTORS
- AUXILIARY DRIVING ELEMENTS
- CONFLICTIVE ROAD SITUATIONS
- SAFETY EFFECTS
INTRODUCTION

- HUMAN FACTORS:
  - FIELD OF VISION: $\geq 120^\circ$ (EU)  
  - VISUAL OBSTRUCTIONS:
    - VEHICLE’ BODYWORK
    - EXTERNAL ELEMENTS: TREES, BUILDINGS,...
  - ELDERLY DRIVERS:
    - REDUCED VISUAL ACUITY
    - REDUCED FIELD OF VISION
    - LOSS OF REFLEXES
    - LOSS OF LIMB MOBILITY:

ROAD DESIGNERS MUST ADAPT INFRAESTRUCTURES TO THEIR CAPABILITIES
INTRODUCTION

- AUXILIARY DRIVING ELEMENTS FOR INDIRECT VISION:
  - MIRROR SYSTEM
  - CAMERA-MONITOR SYSTEM
  - OBSTACLE DETECTION SYSTEM
  ≥ 11°
INTRODUCTION

- CONFLICTIVE ROAD SITUATIONS:
  - SKEWED INTERSECTIONS
  - MERGING AREAS
  - LANE CHANGING
INTRODUCTION

- **SKEWED INTERSECTIONS:**

  - **LEFT SKEWED INTERSECTION**
  - **RIGHT SKEWED INTERSECTION**
INTRODUCTION

- SKEWED INTERSECTIONS:
  - LEFT SKEWED INTERSECTION
  - RIGHT SKEWED INTERSECTION

MAIN ROAD

GUIDELINES: $\phi \geq 60^\circ$
INTRODUCTION

- **SKEWED INTERSECTIONS:**

- **Right-angle intersections with oblique-angle crossing**

  **There are skewed intersections with right-angle crossing**

  **There are right-angle intersections with oblique-angle crossing**
INTRODUCTION

- MERGING AREAS:
SAFETY EFFECTS:

- LITTLE INFORMATION IS AVAILABLE:
  - HANNA et al. (1976):
    - Y intersections had accident rates ≈50% higher than T inters.
  - MCCOY et al. (1994):
    - Accidents increase with increasing skew angle
  - KULMALA (1995):
    - Acute and obtuse skew angles affected safety differently
  - GATTIS and LOW (1997):
    - Vehicles with opaque bodywork at left-skewed intersections: maximum obliquity angle of 15°
  - HARWOOD et al. (1999):
    - Selected AMF for intersection skew angle
  - SON et al. (2002):
    - Right lateral visibility (B-pillar) at left-skewed intersections: obliquities greater than 20° are excessive
  - ARNDT and TROUTBECK (2005):
    - An increase in observation angle will increase accident rates
FIELD STUDY

- EFFECTIVE ANGLES OF VISION THROUGH REAR-VIEW MIRRORS:
  - MEASURING DEVICE
  - RESULTS

- DESIGN VEHICLE:
  - REPRESENTATIVE DIMENSIONS
FIELD STUDY

- MEASURING DEVICE:
FIELD STUDY

RESULTS:

<table>
<thead>
<tr>
<th>VISION ANGLES THROUGH REAR-VIEW MIRRORS</th>
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<tbody>
<tr>
<td><strong>Vision Angle (°)</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>40,0</td>
</tr>
<tr>
<td>35,0</td>
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<tr>
<td>30,0</td>
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<tr>
<td>25,0</td>
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<tr>
<td>20,0</td>
</tr>
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<td>15,0</td>
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<table>
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<tr>
<th>Rear-View Mirror and Position</th>
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<tr>
<td>LF/FW</td>
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<table>
<thead>
<tr>
<th>DESIGN ANGLES</th>
<th>LEFT MIRROR</th>
<th>RIGHT MIRROR</th>
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</thead>
<tbody>
<tr>
<td>BACKWARD POSITION</td>
<td>16°</td>
<td>13°</td>
</tr>
<tr>
<td>COMFORTABLE POSITION</td>
<td>20°</td>
<td>16°</td>
</tr>
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</table>

Average Angles

Maximum Angles

Minimum Angles

10th Percentile Angles
FIELD STUDY

- DESIGN VEHICLE – DIMENSIONS:

  HEAD TURN ≈ 50°

  FIELD OF VISION SEMI-ANGLE = 60°

  DIRECT FIELD OF VISION = 220°
APPLICATIONS

- SKEWED INTERSECTIONS
- MERGING AREAS
APPLICATIONS

SKEWED INTERSECTIONS:

RIGHT SKEWED INTERSECTIONS:
• DEVIATIONS BELOW 20° ARE ACCEPTABLE

LEFT SKEWED INTERSECTIONS:
• THE PREVIOUS RECOMMENDATIONS MUST PREVAIL:
  • VEHICLES WITH LATERAL OPAQUE BODYWORKS
APPLICATIONS

- MERGING AREAS:

  MERGING ANGLE $\leq 7^\circ$
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CURRENT RESEARCH

NEW KINEMATIC MODEL THAT BETTER REPRESENTS THE PROCESS OF MERGING:

- MAIN AND MERGING ROAD GEOMETRY
- RELATIVE KINEMATICS OF THE VEHICLES:
  - Trajectories
  - Speeds
  - Accelerations/Decelerations
- DRIVER SCANNING BEHAVIOR:
  - Eyes fixed (Peripheral vision only)
  - Eyes only scan (Left/Right, no head motion)
  - Eye/Head scan (Head rotates but no change in position)
  - Active scan (Head moves around left/right and forward/backward)
- MOVEMENT OF THE SIGHT TRIANGLES
CURRENT RESEARCH

- TRACKING VEHICLE/DRIVER BEHAVIOR:
  - OBSERVATION
CURRENT RESEARCH

- TRACKING VEHICLE/DRIVER BEHAVIOR:
  - RESTITUTION MODEL
CURRENT RESEARCH

- OBSERVED TRAJECTORIES:
  - PARALLEL
  - TANGENT
  - OPEN
  - CUTTING
CURRENT RESEARCH

- TRAJECTORY: CUTTING
- SCANNING: REAR-VIEW MIRROR
CURRENT RESEARCH

- TRAJECTORY: TANGENT
- SCANNING: REAR-VIEW MIRROR
CURRENT RESEARCH

- TRAJECTORY: TANGENT
- SCANNING: HEAD MOTION
CURRENT RESEARCH

- TRAJECTORY: PARALLEL
- SCANNING: HEAD MOTION
CURRENT RESEARCH

- **TRAJECTORY**: OPENED, BUT FINALLY CUTTING
- **SCANNING**: HEAD MOTION AND REAR-VIEW MIRROR
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PROPOSALS

ALTERNATIVE 1

ALTERNATIVE 2
FUTURE

- STRATEGIC GEOMETRIC DESIGN RESEARCH NEEDS (PLAN from AASHTO and TRB):
  - ONE OF THE PRIORITY RESEARCH TOPICS:
    - “Safety Effects of Intersection Skew Angle”
      - RESEARCH OBJECTIVE:
        - To establish quantitative relationships between intersection skew angle and safety, and
        - To use those relationships to consider the need for revision of current geometric design policies concerning intersection skew angle