



GIORNATA di STUDIO S.I.I.V. La Sicurezza Stradale nell'Adeguamento della Viabilità Esistente



SAFETY EFFECTS OF SKEWED INTERSECTIONS



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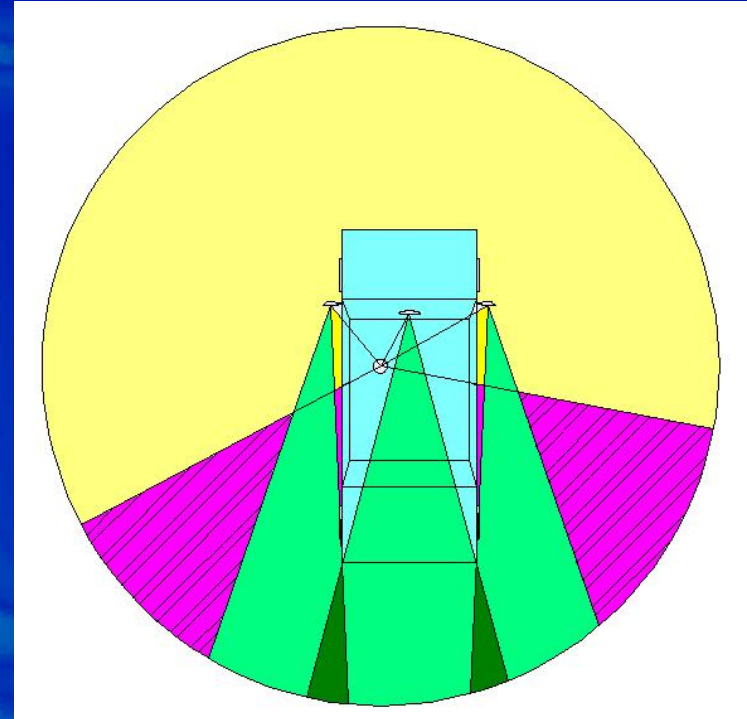
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ESPAÑA**

Catania (Italia)

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CONTENTS

- **INTRODUCTION**
- **FIELD STUDY**
- **APPLICATIONS**
- **CONCLUSIONS**
- **CURRENT RESEARCH**
- **PROPOSALS**



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)** 120°
- ◆ **VISUAL OBSTRUCTIONS:**
 - VEHICLE' BODYWORK
 - EXTERNAL ELEMENTS: TREES, BUILDINGS,...
- ◆ **ELDERLY DRIVERS:**
 - REDUCED VISUAL ACUITY
 - REDUCED FIELD OF VISION
 - LOSS OF REFLEXES
 - LOSS OF LIMB MOBILITY:

PERIPHERAL VISION

FOCAL VISION



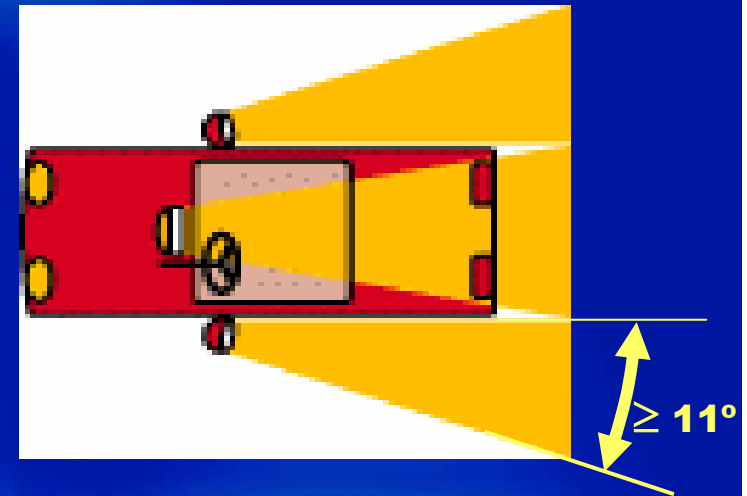
**ROAD DESIGNERS MUST
ADAPT
INFRASTRUCTURES TO
THEIR CAPABILITIES**



INTRODUCTION

■ AUXILIARY DRIVING ELEMENTS FOR INDIRECT VISION:

- ◆ MIRROR SYSTEM
- ◆ CAMERA-MONITOR SYSTEM
- ◆ OBSTACLE DETECTION SYSTEM



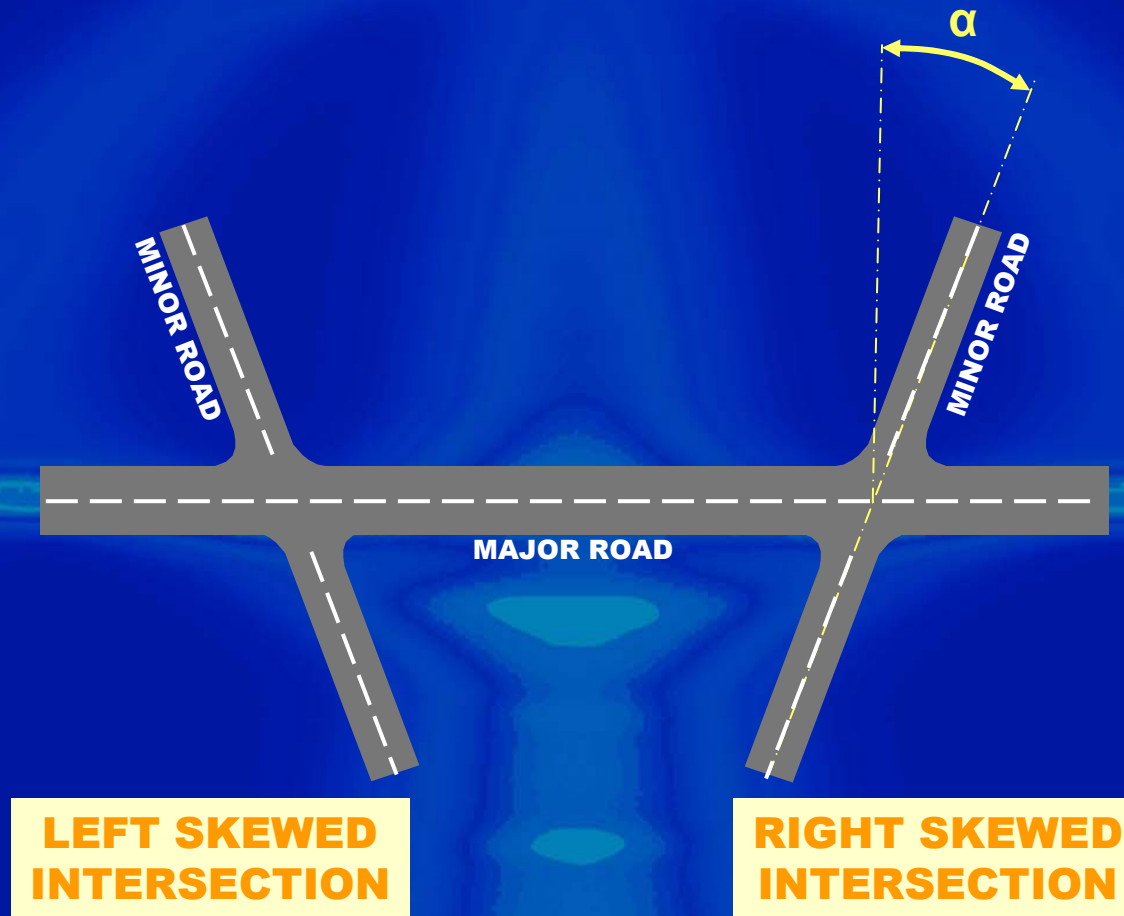
INTRODUCTION

- **CONFLICTIVE ROAD SITUATIONS:**
 - ◆ **SKEWED INTERSECTIONS**
 - ◆ **MERGING AREAS**
 - ◆ **LANE CHANGING**



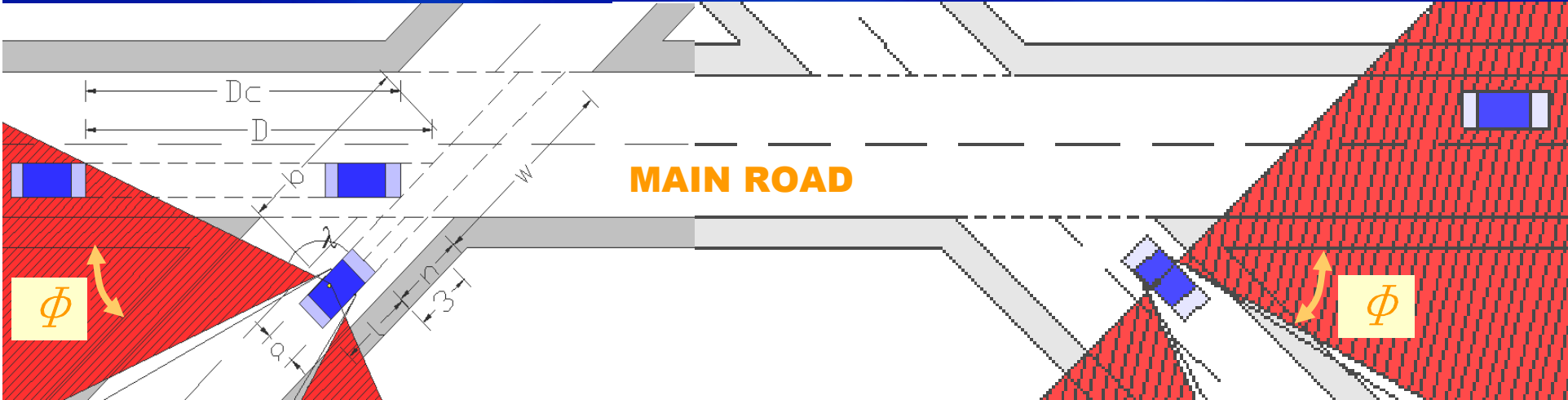
INTRODUCTION

- **SKEWED INTERSECTIONS:**



INTRODUCTION

- SKEWED INTERSECTIONS:**



RIGHT SKEWED INTERSECTION

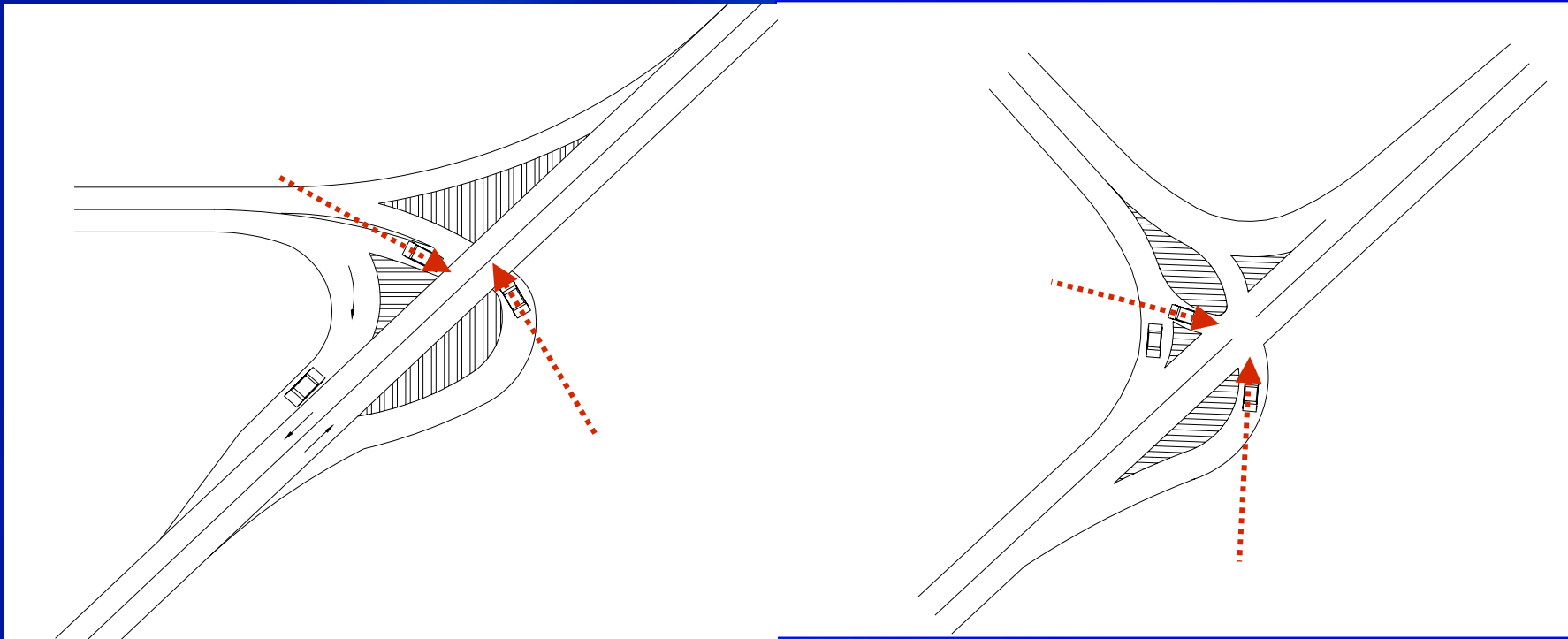
LEFT SKEWED INTERSECTION

GUIDELINES: $\Phi \geq 60^\circ$



INTRODUCTION

■ SKEWED INTERSECTIONS:



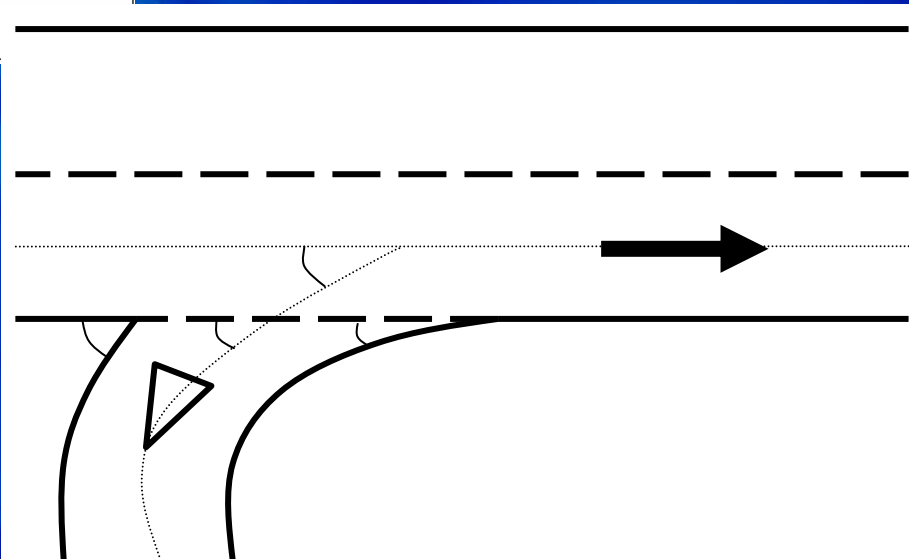
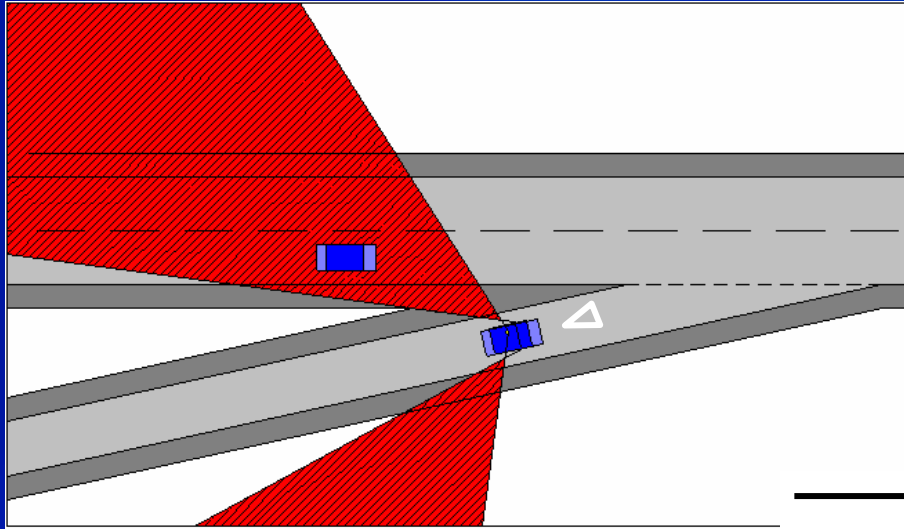
**THERE ARE SKEWED
INTERSECTIONS WITH
RIGHT-ANGLE CROSSING**

**THERE ARE RIGHT-ANGLE
INTERSECTIONS WITH
OBLIQUE-ANGLE CROSSING**



INTRODUCTION

■ MERGING AREAS:



INTRODUCTION

■ SAFETY EFFECTS:

◆ LITTLE INFORMATION IS AVAILABLE:

- **HANNA et al. (1976):**
 - Y intersections had accident rates $\approx 50\%$ 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



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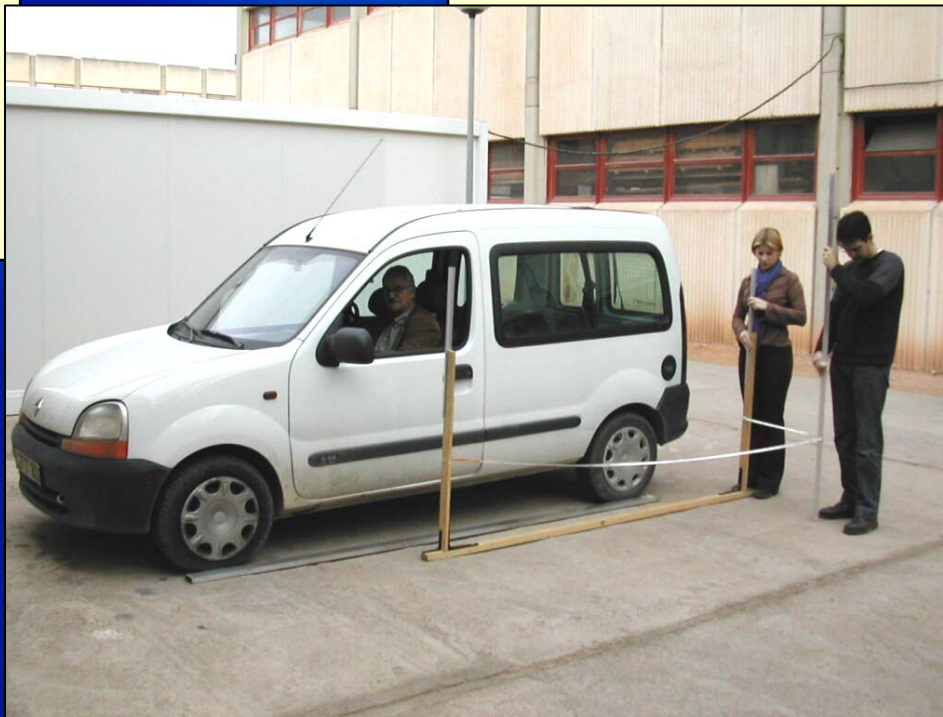
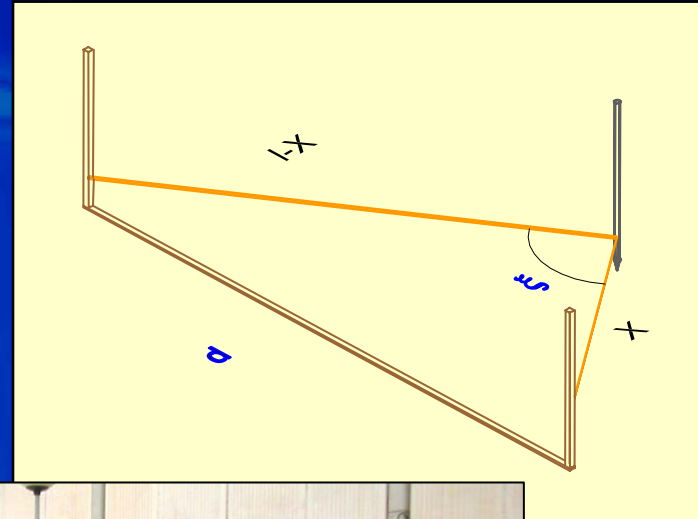
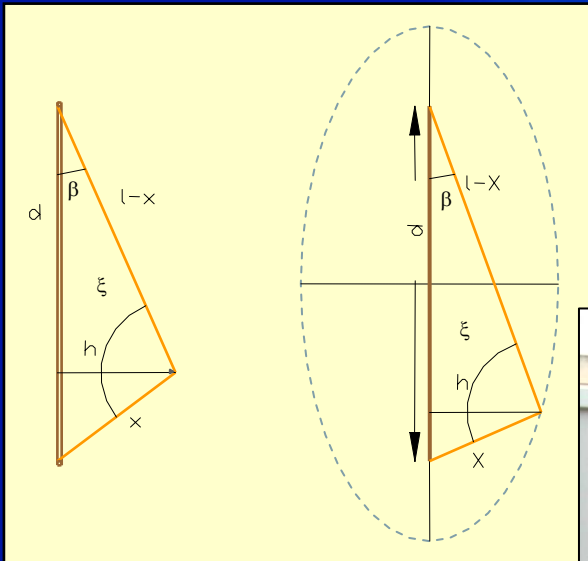
FIELD STUDY

- **EFFECTIVE ANGLES OF VISION THROUGH REAR-VIEW MIRRORS:**
 - ◆ **MEASURING DEVICE**
 - ◆ **RESULTS**
- **DESIGN VEHICLE:**
 - ◆ **REPRESENTATIVE DIMENSIONS**



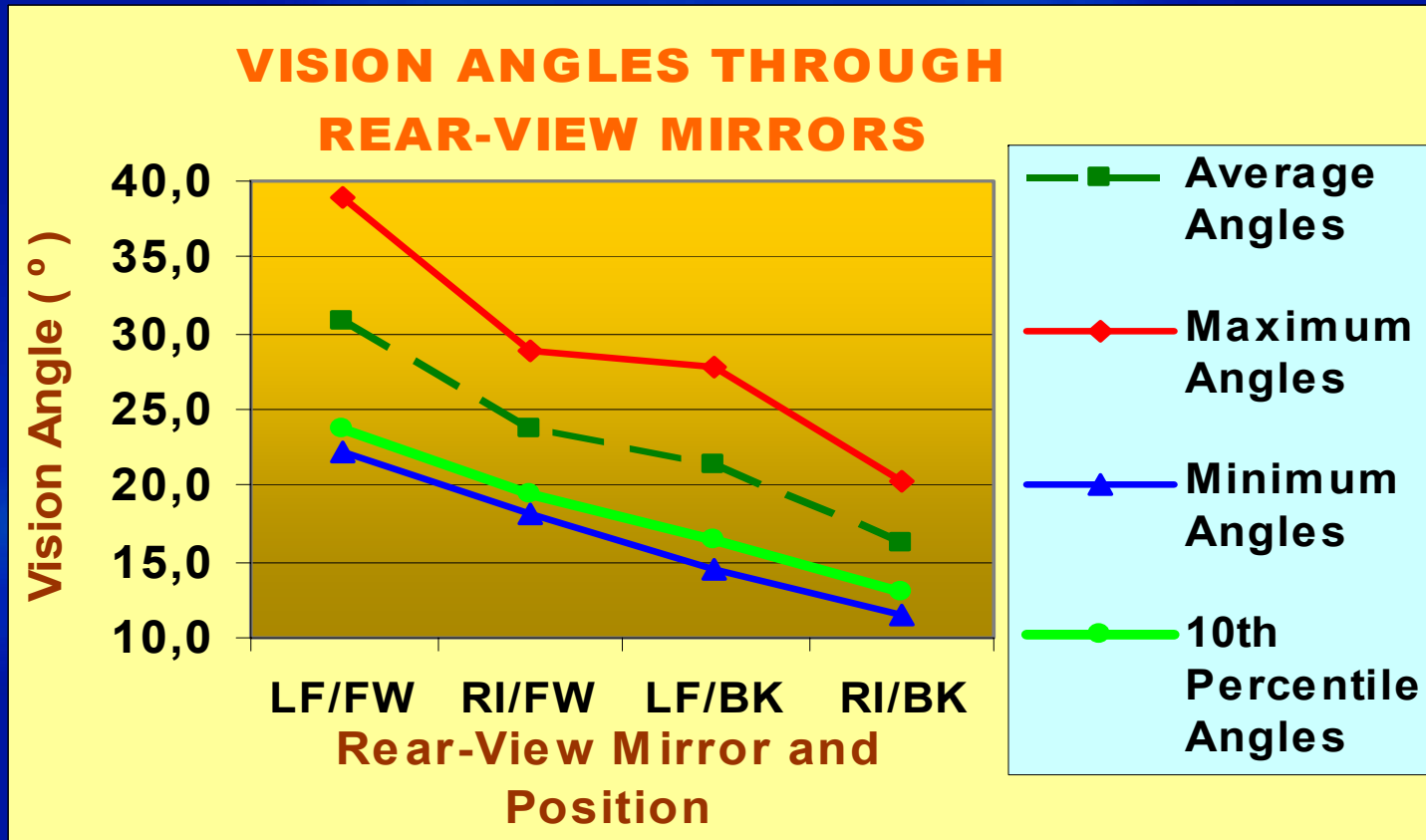
FIELD STUDY

MEASURING DEVICE:



FIELD STUDY

RESULTS:

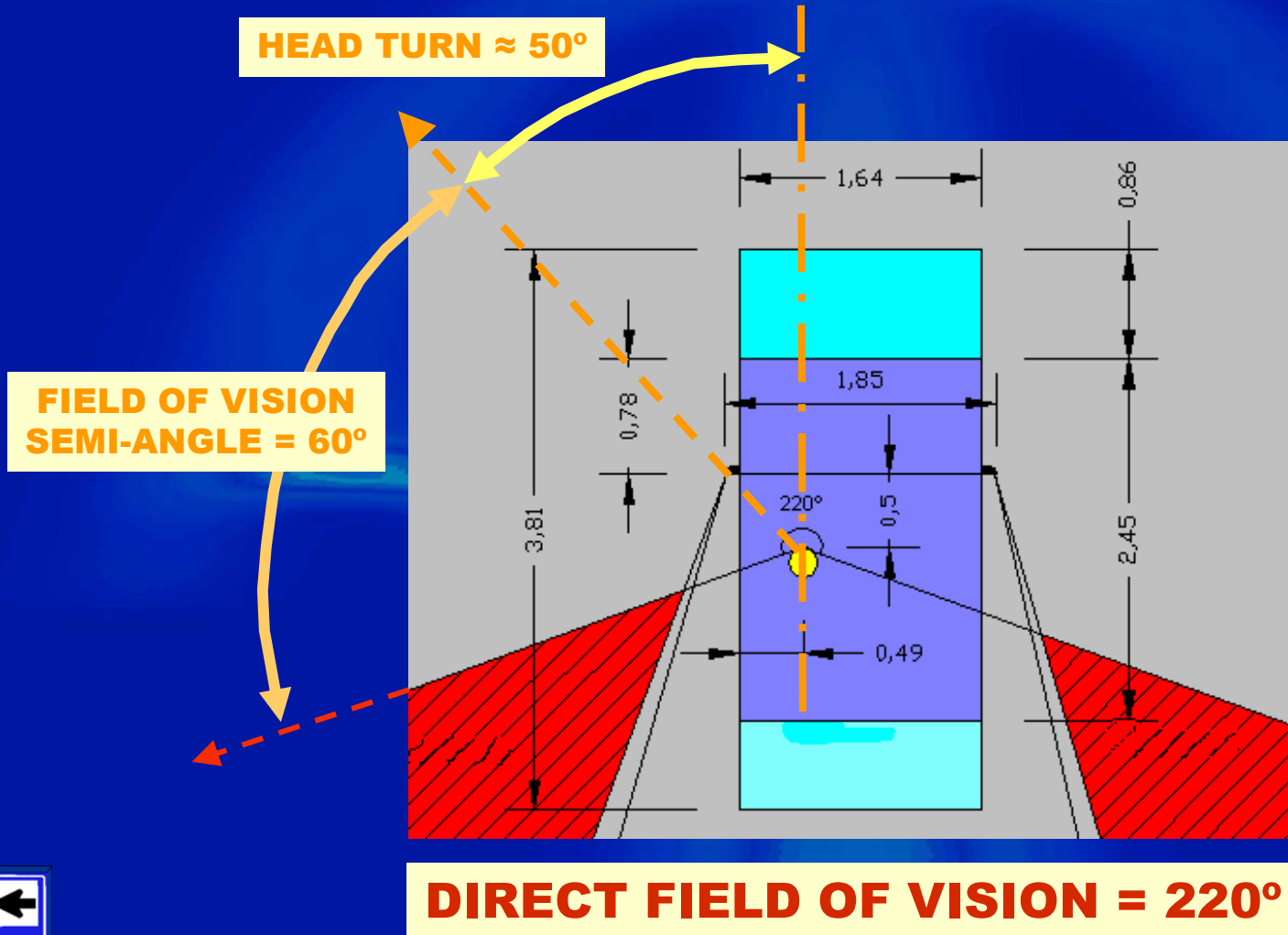


DESIGN ANGLES	LEFT MIRROR	RIGHT MIRROR
BACKWARD POSITION	16°	13°
COMFORTABLE POSITION	20°	16°



FIELD STUDY

■ DESIGN VEHICLE – DIMENSIONS:



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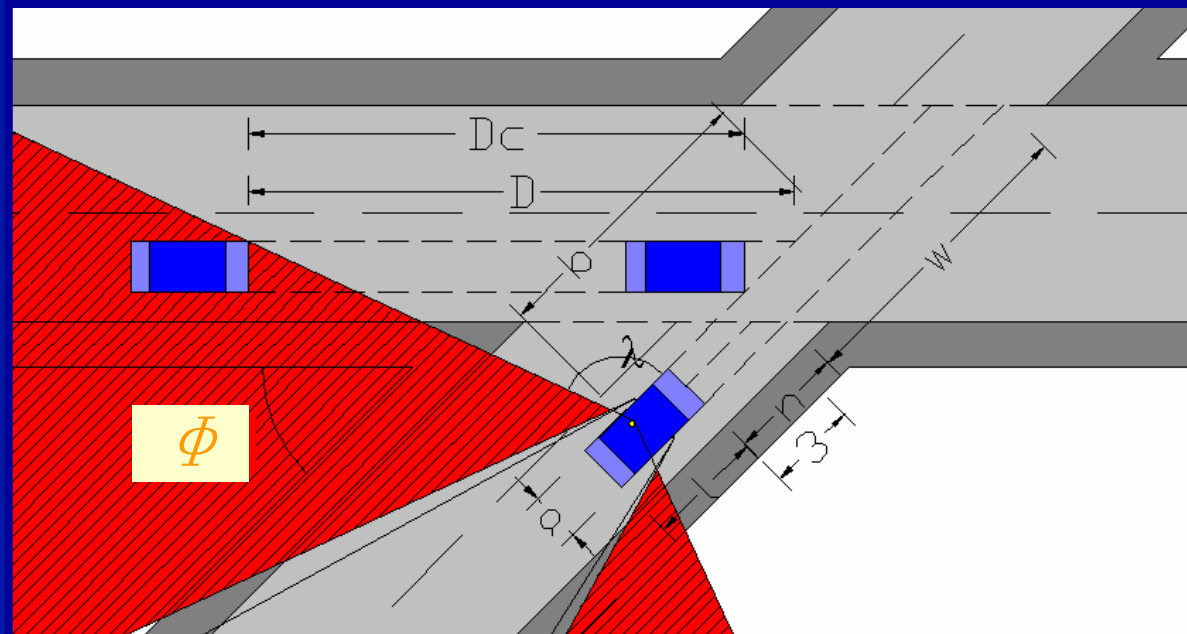
APPLICATIONS

- **SKEWED INTERSECTIONS**
- **MERGING AREAS**



APPLICATIONS

■ SKEWED INTERSECTIONS:



RIGHT SKEWED INTERSECTIONS:

- DEVIATIONS BELOW 20° ARE ACCEPTABLE



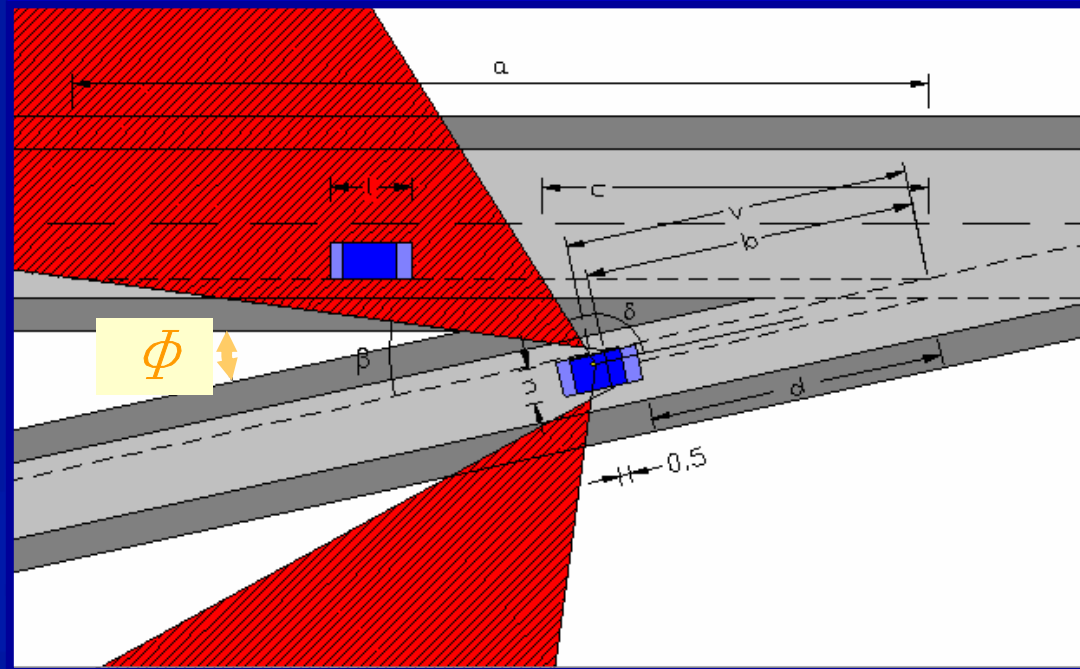
LEFT SKEWED INTERSECTIONS:

- THE PREVIOUS RECOMMENDATIONS MUST PREVAIL:
- VEHICLES WITH LATERAL OPAQUE BODYWORKS



APPLICATIONS

■ MERGING AREAS:



☞ **MERGING ANGLE $\leq 7^\circ$**

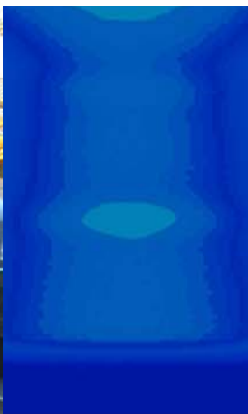
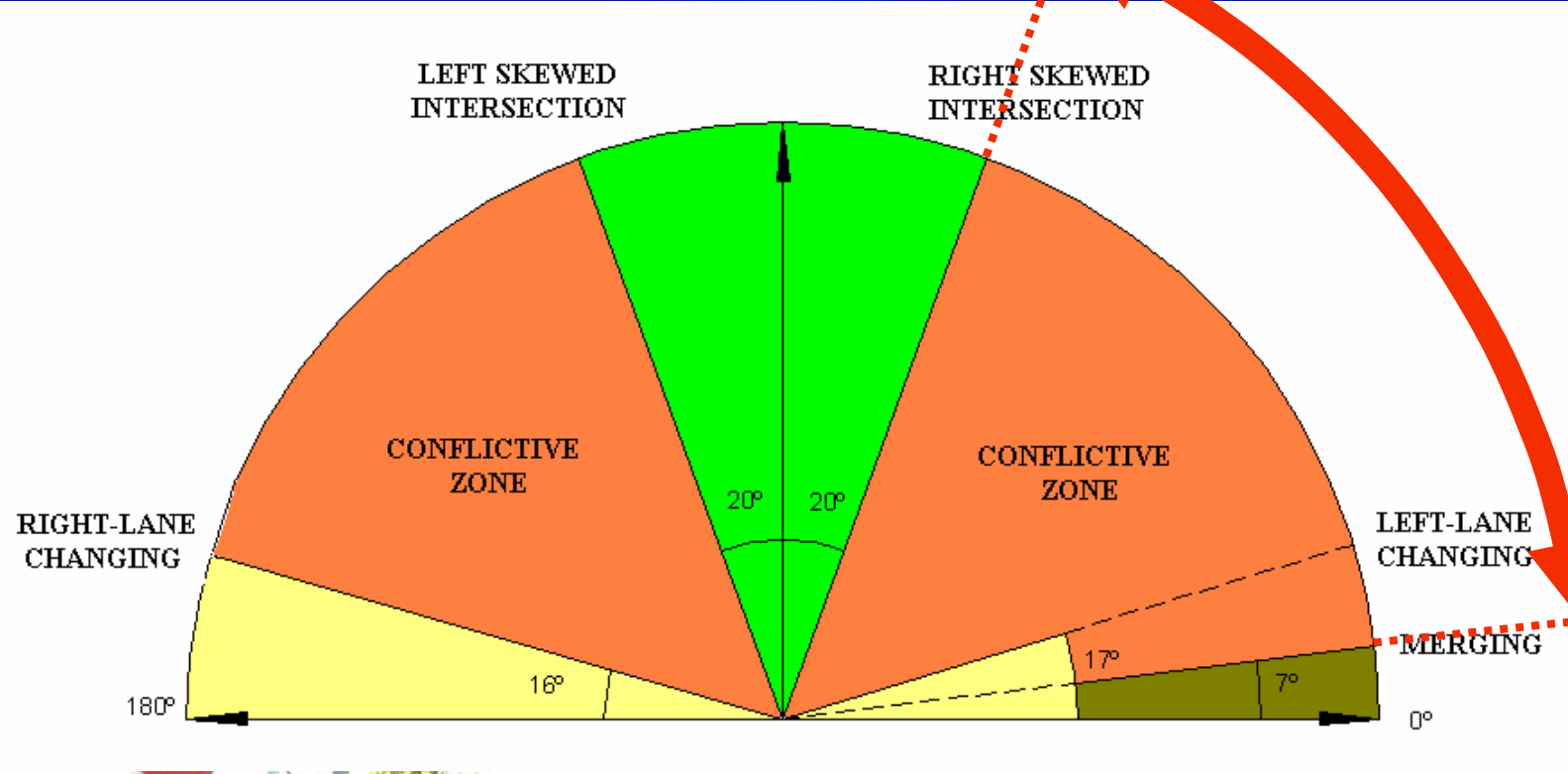


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CONCLUSIONS



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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**



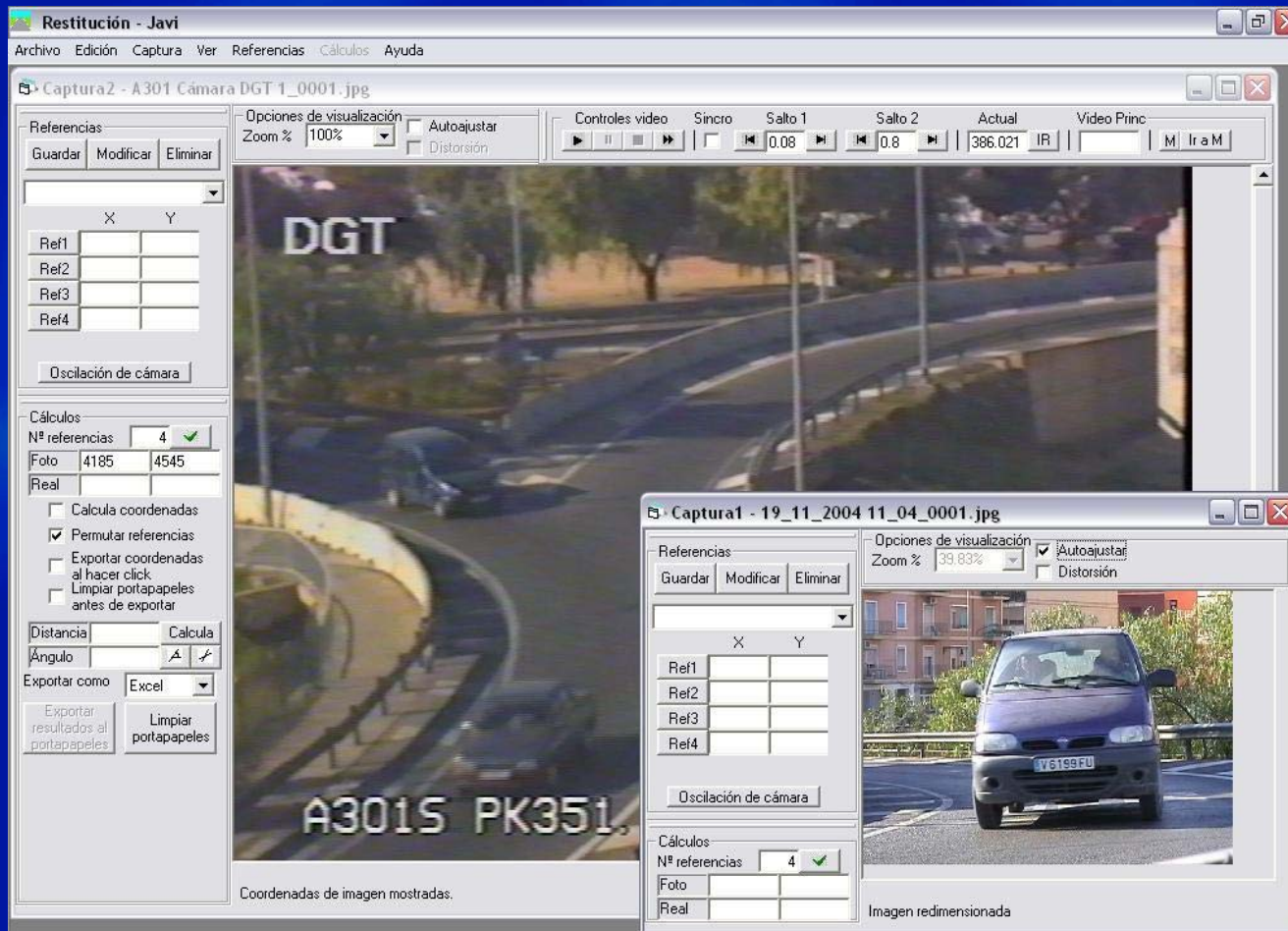
CURRENT RESEARCH

- **TRACKING VEHICLE/DRIVER BEHAVIOR:**
 - ◆ **OBSERVATION**



CURRENT RESEARCH

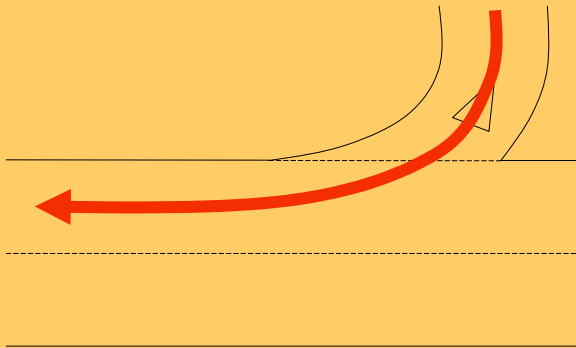
TRACKING VEHICLE/DRIVER BEHAVIOR: RESTITUTION MODEL



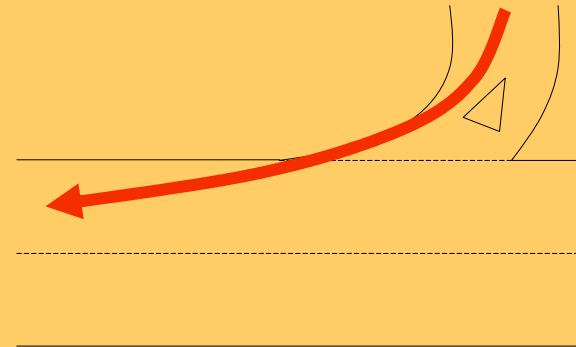
CURRENT RESEARCH

■ OBSERVED TRAJECTORIES:

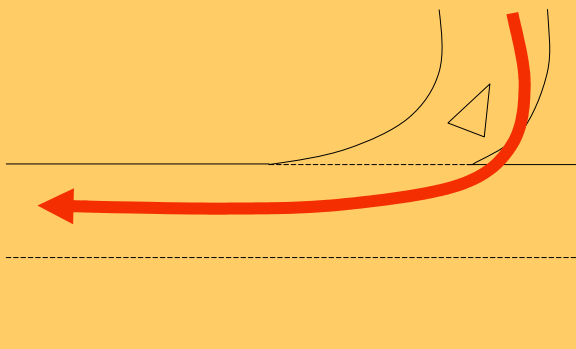
PARALLEL



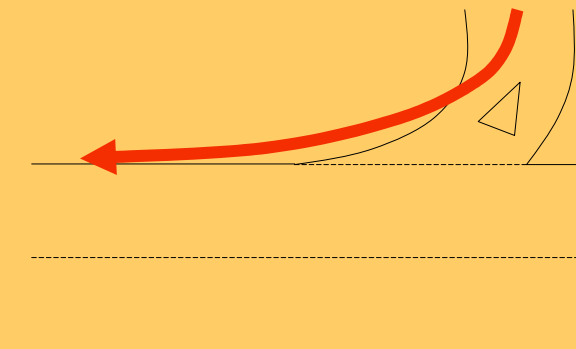
TANGENT



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**



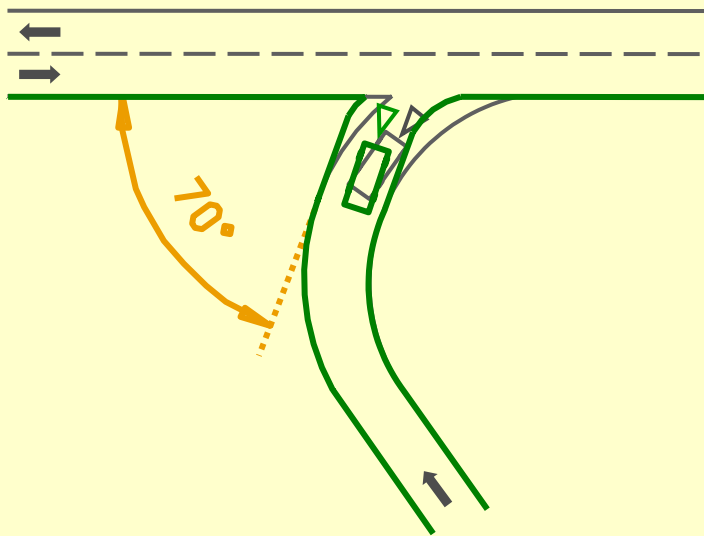
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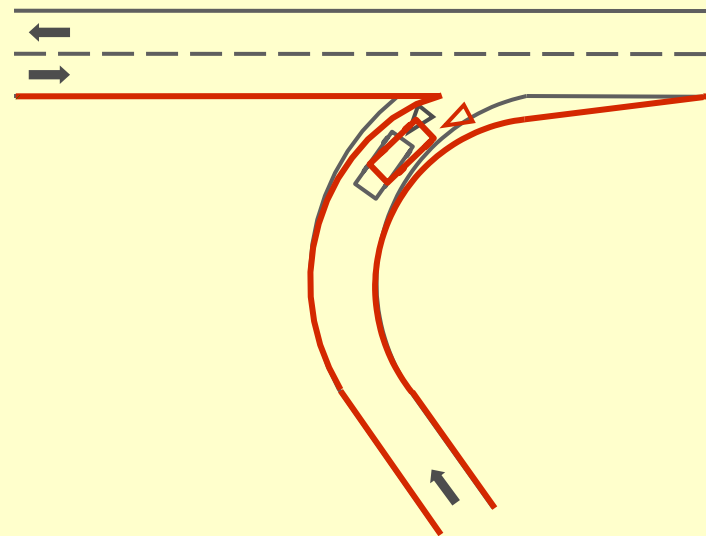


PROPOSALS

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**

