Crash Scenario Framework (Track 1) and Benefits Assessment (Track 3)

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Crash Scenario Framework

**Task 1**
Update 37 Pre-Crash Scenarios
- Statistics
- Causal Factors
- Kinematics
  (High Level)

**Task 2**
Priority Scenario Depictions
- Crash Time Line
- Critical Event
  (Scenario Details)

**Task 3**
Safety Application Profiles
- Requirements
- Performance Specifications
- Functions
  (Application Details)

**V2V Prototype Safety Applications**

Identify and describe crash problems

Connect scenarios to V2V-based countermeasures
Define functions/performance requirements
Target V2V Crash Scenarios

- Lead vehicle stopped
- SCP @ non-signalized junction
- Lead vehicle decelerating
- Changing lanes/same direction
- Running red light
- LTAP/OD @ signalized junction
- Turning/same direction
- Lead vehicle @ lower speed
- LTAP/OD @ non-signalized junction
- Opposite direction/no maneuver
- Drifting/same direction
- Rear-end/striking maneuver
- Turn @ non-signalized junction
- Running stop sign
- Turn right @ signalized junction
- Lead vehicle accelerating
- Opposite direction/maneuver

17 target pre-crash scenarios

SCP: Straight Crossing Paths
LTAP/OD: Left Turn Across Path/ Opposite Direction

Annual Crash Frequency

- 200,000
- 400,000
- 600,000
- 800,000
- 1,000,000
# Crash Scenario Statistics

<table>
<thead>
<tr>
<th>General Estimates System</th>
<th>National Motor Vehicle Crash Causation Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Alignment</td>
<td>Critical Reason for Critical Precrash Event</td>
</tr>
<tr>
<td>Roadway Surface Condition</td>
<td>Driver Fatigue</td>
</tr>
<tr>
<td>Atmospheric Conditions</td>
<td>Driver Inattention</td>
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<tr>
<td>Relation to Junction</td>
<td>Driver Conversing</td>
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<tr>
<td>Traffic Control Device</td>
<td>Driver Inadequate Surveillance</td>
</tr>
<tr>
<td>Lighting Condition</td>
<td>Other Driver Recognition Factor</td>
</tr>
<tr>
<td>Speed Limit</td>
<td>Misjudgement of Distance/Speed of Other Vehicle</td>
</tr>
<tr>
<td>Driver Age</td>
<td>False Assumption of Other Road User’s Action</td>
</tr>
<tr>
<td>Driver Gender</td>
<td>Following Too Closely</td>
</tr>
<tr>
<td>Alcohol Involvement</td>
<td>Other Driver Decision Factor</td>
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<tr>
<td>Drug Involvement</td>
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<tr>
<td>Physical Impairment</td>
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<tr>
<td>Violations Charged</td>
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<tr>
<td>Speed Related</td>
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<tr>
<td>Driver Vision Obscured By</td>
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<tr>
<td>Driver Distracted By</td>
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<tr>
<td>Vehicle Contributing Factors</td>
<td></td>
</tr>
</tbody>
</table>

### Event Data Recorder

- **% Vehicles @ Brake Onset**
- **Time To-Collision (s)**

- 0% @ -5 s
- 20% @ -4 s
- 40% @ -3 s
- 60% @ -2 s
- 80% @ -1 s

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U.S. Department of Transportation
Target V2V Scenario Prioritization

**Opposite Direction**
- Opposite direction/maneuver: 1.7%
- Opposite direction/no maneuver: 14.7%
- Straight crossing paths @ non-signal: 20.4%
- Left turn across path/opposite direction: 15.1%
- Drifting/same direction: 1.7%
- Turning/same direction: 3.1%
- Changing lanes/same direction: 4.2%
- Lead vehicle constant speed: 5.1%
- Rear End
- Lead vehicle decelerating: 6.1%
- Lead vehicle stopped: 14.8%

**% Comprehensive Cost**
Priority V2V Scenario Depiction

Rear-End/Lead Vehicle Stopped

\[ ttc = \frac{D_0}{V_i} \]

- \( ttc \) = Time-to-collision
- \( D_0 \) = Distance between vehicles
- \( V_i \) = Vehicle i speed
## V2V Countermeasure Needs

<table>
<thead>
<tr>
<th>Information Needs</th>
<th>Pre-Crash Scenario Group</th>
<th>Rear-End</th>
<th>Opposite Direction</th>
<th>LTAP/OD</th>
<th>SCP @ Non Signal</th>
<th>Lane Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Position</td>
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<td>Range Rate</td>
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<td>✓</td>
<td>✓</td>
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<td>Position in Lane</td>
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<tr>
<td>Other: Wiper state, temperature, turn signal status, throttle, brake, etc.</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>

**SCP**: Straight Crossing Paths  
**LTAP/OD**: Left Turn Across Path/Opposite Direction
## Mapping to Safety Applications

<table>
<thead>
<tr>
<th>Target Pre-Crash Groups and Scenarios</th>
<th>V2V Safety Applications</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>EEBL</td>
</tr>
<tr>
<td>Rear-End</td>
<td></td>
</tr>
<tr>
<td>Lead Vehicle Stopped</td>
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<tr>
<td>Lead Vehicle Moving</td>
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<tr>
<td>Lead Vehicle Decelerating</td>
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<tr>
<td>Junction Crossing</td>
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<tr>
<td>SCP @ Non Signal</td>
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<tr>
<td>LTAP/OD</td>
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<tr>
<td>LTAP/OD</td>
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<tr>
<td>Opposite Direction</td>
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</tr>
<tr>
<td>Opposite Direction/No Maneuver</td>
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</tr>
<tr>
<td>Opposite Direction/Maneuver</td>
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<tr>
<td>Lane Change</td>
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<tr>
<td>Changing Lanes/Same Direction</td>
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<tr>
<td>Turning/Same Direction</td>
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<tr>
<td>Drifting/Same Direction</td>
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</tbody>
</table>

**EEBL:** Electronic Emergency Brake Light  
**IMA:** Intersection Movement Assist  
**DNPW:** Do Not Pass Warning  
**BSW:** Blind Spot Warning  
**LCW:** Lane Change Warning  
**FCW:** Forward Crash Warning
Countermeasure Functions

- Sensing and Perception
  - Monitor vehicle
  - Perceive roadway
  - Perceive obstacles

- Situation Characterization and Threat Assessment
  - Determine road conditions
  - Integrate data: vehicle, target, roadway, and road conditions
  - Assess threats
  - Arbitrate threats
  - Determine driver conditions
  - Identify false alarms

- Presentation of Crash-Avoidance Information
  - Commands to vehicle
  - Cues and displays to driver

- System Management
  - Driver inputs
  - Data integrity, diagnostics, raw data
  - System status messages
Benefits Assessment
Performance Measures & Requirements

Crash Avoidance Groups

- Rear-End
- Lane Change
- Opposite Direction
- LTAP/OD
- Junction Crossing

Methodology

- Related Literature
- Supporting Data
- Analysis & Assumptions

Recommended Performance Measures and Requirements
Objective Test Procedures

- Produce guidelines for objective tests
- Develop test procedures:
  - Aftermarket safety devices
  - Track 4 systems
- Conduct tests:
  - Qualification – aftermarket safety devices
  - Characterization – Track 4 systems
Independent Evaluation of Safety Pilot

- Assess the safety impact of DSRC-based safety applications:
  - Overall driving behavior
  - Exposure and response to near crashes
  - Driver attention
  - Impact of deployment rate

- Determine driver acceptance:
  - Ease of use
  - Usefulness
  - Ease of learning
  - Willingness to use/Advocacy
  - Privacy

- Characterize system performance and capability:
  - Accuracy
  - Interoperability
  - Security
  - Alert logic
  - Driver-vehicle interface