NHTSA's Surrogate Strikeable Vehicle for Forward Collision Avoidance and Mitigation Testing

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Acronyms

- **CIB**: Crash imminent braking, provides automatic braking
- **FCW**: Forward collision warning, typically visual and auditory
- **DBS**: Dynamic brake support, automatically provides supplemental braking
- **MTRI**: Michigan Technical Research Institute
- **NCAP**: NHTSA’s New Car Assessment Program
- **RCS**: Radar cross section
- **SS_V**: Strikeable surrogate vehicle
- **UHMW**: Ultra high molecular weight (plastic)
- **UMTRI**: University of Michigan Transportation Research Institute
- **VRTC**: NHTSA’s Vehicle Research and Test Center
Why The SS_V Was Developed

- Any regulatory evaluation of FCW/CIB/DBS requires a realistic lead vehicle.
- FCW tests can be performed with a real lead vehicle because impacts with the test vehicle are not expected.
- CIB/DBS tests often produce test-to-lead vehicle collisions, therefore real lead vehicles cannot be used.
- All known surrogate vehicles have some undesirable attributes.
- Inconsistent CIB/DBS test track performance has been observed at VRTC; the possibility of the surrogate being the cause cannot be overlooked.

The surrogate vehicles presently used by NHTSA are research tools, and may not be suitable for regulatory use.
# Surrogate Vehicle Comparison

<table>
<thead>
<tr>
<th>Surrogate</th>
<th>Construction</th>
<th>Visual Characteristics</th>
<th>Durability</th>
<th>Radar Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHTSA Foam Car 1 (FC1)</td>
<td>Covered foam frame</td>
<td>No</td>
<td>Yes (but better elements are necessary)</td>
<td>Acceptable</td>
</tr>
<tr>
<td>NHTSA Foam Car 2 (FC2)</td>
<td>Covered foam frame</td>
<td>Yes</td>
<td>Yes</td>
<td>Unknown</td>
</tr>
<tr>
<td>Euro NCAP/Thatcham/ADAC</td>
<td>Covered inflatable</td>
<td>No</td>
<td>Yes</td>
<td>Unknown</td>
</tr>
</tbody>
</table>
Strikeable Surrogate Concept

- A new design from the ground up
- Rigid “shell” provides a stable, consistent presence
- Incorporates a slider-and-load frame assembly
  - Helps diffuse impact energy
  - Installed on a trailered guide rail to accurately maintain a known distance to its tow vehicle (until an impact occurs)
- Installed on a road-based monorail to minimize lateral runout
- Can be used to perform common rear end crash scenarios
  - Lead vehicle stopped
  - Slower moving lead vehicle
  - Decelerating lead vehicle
Strikeable Surrogate Basis

• Emulates the rear of a 2011 Ford Fiesta
  – Platform is sold worldwide
  – Hatchback design facilitates a lightweight surrogate

• Carbon fiber construction
  – Stiff (promotes a consistent presence)
  – Lightweight (less mass = less severe impacts)
  – Robust (when properly implemented)
  – Conductive (detected by radar)
Modified Dimensional Scan

Bumper contour flattened to accommodate impacts with a wide variety of bumper heights
Lightweight Carbon Fiber Shell

Prototype. Rear window later replaced with Kevlar to improve radar return characteristics.
Realistic Design Elements

OE taillights, reflectors, and third brake light
Vinyl wrap simulates paint and a tinted rear window
3-dimensional from center of rear wheels back
Gap between wheels
Simulated license plate covered in reflective material
Installed On A Towed Rail

Kevlar window used to tune radar return (radar transparent)

Hitch-equipped tow vehicle

Absorber used to “hide” towed rail and slider/load frame from radar

Not shown with simulated paint (vinyl wrap) or UHMW skid plates on towed rail
Guided By A Monorail

- Straight track, attached to the pavement
- UHMW guide material
- Design accommodates temperature fluctuations
- Guides the towed rail
- Accurately positions the SS_V within the travel lane
Rear Views

Bulkhead and internal gusset increase rigidity

Not shown with simulated paint (vinyl wrap)
Slider / Load Frame

- Supports the SS_V shell
- Carbon fiber construction
- Interfaces with a towed rail
- Assembled in-house at VRTC

Not shown with bulkhead or internal gusset
Stationary Lead Vehicle Test
(test vehicle: 20 mph)

Video Removed Due to Size Constraints
Slower Moving Lead Vehicle Test
(test vehicle: 25 mph; lead vehicle: 10 mph)

Video Removed Due to Size Constraints
Striking Vehicle Protection
(presently under development)

• Needed to attenuate the initial impact
• Two installation options:
  – Striking vehicle front bumper
  – SS_V rear bumper (not shown)
Radar Characteristics

• Measured by UMTRI/MTRI using Ka and W-bands
  – Evaluated how 24 and 77 GHz radar-based systems “see” the SS_V
  – Scans performed at different elevations, aspects, and azimuths

• Test results
  – The flat “strikeable area” of the SS_V bumper contributes to a strong radar return when approached directly from the rear
  – The SS_V exhibits automobile-like radar scattering characteristics at the tail-aspect for both band radars
  – The SS_V resemblance to real cars degrades with viewing angles further away from the tail
  – The SS_V may be suitable for evaluating radar-based FCW/CIB/DBS
Durability

• Design intent is to withstand 30 mph relative impact speeds
  – 25 mph relative impacts have been performed successfully
  – Repeated 15 mph stationary impacts are reliable
  – Additional durability tests are presently underway

• Other factors:
  – UHMW skids on towed rail have a long service life
  – Most service or repairs can be performed in a basic machine shop
  – If necessary, more extreme shell repairs can be performed by repeating the mold and autoclave process
Summary

• Inherent realism promotes good real-world performance
  – Reduces the potential for gaming
• Design addresses known shortcomings of other surrogate vehicles
  – Balances RCS realism with universal strikeability
  – RCS tuning and robustness evaluations presently underway
  – Industry feedback welcome
• Apparatus may be used at many test sites, for light and heavy vehicles
• Accurate conduct of the decelerating lead vehicle scenario possible should the agency wish to expand it’s test efforts
• Schematics and dimensional scan information to be publicly available
**Docket/Contact Information**

- Docket No. NHTSA-2012-0057
  - Available at [www.Regulations.gov](http://www.Regulations.gov)
  - Will include this presentation
  - SS_V construction details (provided as they become available)
  - SS_V radar return characteristics report (when available)
  - CIB / DBS draft test procedures
  - Responses to NHTSA’s request for comments (RFC) on a research report summarizing the agency’s light vehicle CIB / DBS research efforts

- Technical Contact at VRTC:
  - Garrick Forkenbrock ([garrick.forkenbrock@dot.gov](mailto:garrick.forkenbrock@dot.gov))
Thank you for your attention!