Saving Lives and Reducing Costs Through Crashworthy Light Rail Vehicle Design

John D. Swanson
SNC-Lavalin Rail & Transit, Principal Consultant
Vista, California
Safety Goals for Light Rail Vehicles

- Improved safety for pedestrians in case of contact with an LRV
- Improved safety for road vehicles in case of collision with an LRV
- Improved safety in the LRV interior in case of sudden stops
- Improved safety in case of collision with another LRV

Figure 26. Vehicle and SID response at the time of peak injury.

Figure 27. Neon and Explorer response at late time.
Traditional Light Rail Vehicles

Exposed anti-climbers and massive protruding couplers

Open front can scoop up pedestrians and motor vehicles alike!
Evolution of Leading End Geometry
(deflect instead of trap)

Fully enclosed front end
Sharp / protruding elements eliminated
Fully Enclosed Cab Front & Trucks

w/ Retracted Coupler and Energy Absorbing Bumper
Phoenix Light Rail Vehicle
1st Stage: Energy Absorbing Bumpers

Phoenix Light Rail Vehicle
2nd Stage: Controlled Collapse Cab

Designed for LRV to LRV Collisions
Phoenix Light Rail Vehicle
Valley Metro Rail System

April 2017
Valley Metro Rail System

- Initially a 20 mile long system with 28 stations, currently 26.3 miles with 35 stations - still expanding
- Operates 20 hours / day on 15 minute headways
- Almost entirely in reserved right of way in city streets, but with many intersections (currently 148)
- Each train crosses over 2100 intersections per day
- Service requires 12 trains = over 25,500 street crossings per day! (~ 9.3 million crossings per year)

Collisions are inevitable!
Ridership Growth

42% increase in rail boardings from 2009 to 2016

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Annual Boardings</th>
<th>Average Weekday</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>11,348,343</td>
<td>34,828</td>
</tr>
<tr>
<td>2010</td>
<td>12,616,937</td>
<td>39,405</td>
</tr>
<tr>
<td>2011</td>
<td>13,161,638</td>
<td>40,712</td>
</tr>
<tr>
<td>2012</td>
<td>14,042,008</td>
<td>43,268</td>
</tr>
<tr>
<td>2013</td>
<td>14,226,293</td>
<td>43,619</td>
</tr>
<tr>
<td>2014</td>
<td>14,263,662</td>
<td>43,860</td>
</tr>
<tr>
<td>2015</td>
<td>14,759,817</td>
<td>44,716</td>
</tr>
<tr>
<td>2016</td>
<td>14,935,246</td>
<td>49,416</td>
</tr>
</tbody>
</table>
Valley Metro Rail System
Eight Years of Collisions

259 total collisions from 2009 thru 2016

On average 2.7 Collisions / Month
The Second Learning Curve

Possible Factors:
- Six new LRT miles
- First full year of Central Mesa Ext.
- Opening of Northwest Ext.

<table>
<thead>
<tr>
<th>Year</th>
<th>Extensions Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>53</td>
</tr>
<tr>
<td>2010</td>
<td>25</td>
</tr>
<tr>
<td>2011</td>
<td>28</td>
</tr>
<tr>
<td>2012</td>
<td>28</td>
</tr>
<tr>
<td>2013</td>
<td>29</td>
</tr>
<tr>
<td>2014</td>
<td>21</td>
</tr>
<tr>
<td>2015</td>
<td>32</td>
</tr>
<tr>
<td>2016</td>
<td>43</td>
</tr>
</tbody>
</table>
Types of Collisions

No LRV to LRV Collisions!
Only 1 minor collision due to Operator error
Autos – Improper Left Turns
Autos – Run Red Light
Pedestrians
Total Persons Injured

148 persons injured in eight years

Includes LRT passengers & other road users
58 passengers were injured inside LRV due to fall from rapid stops, etc.

- 38% of persons injured were on a light rail vehicle
- On LRV: 38%
- Other Road Users/Unknown: 62%

“On LRV” includes passengers and operators
“Unknown” if injured person was on LRV in some instances
Severity of Injuries - Auto

- None Reported: 68%
- Person Transported: 19%
- Minor/Treated on Scene: 8%
- Unknown: 4%
- Fatal: <1%

227 Collisions
Severity of Injuries - Pedestrians

- None Reported: 43%
- Person Transported: 39%
- Minor/Treated on Scene: 11%
- Unknown: 4%
- Fatal: 3%
- Total Collisions: 28
Accident Damage

Damage Mostly Cosmetic
Accident Damage

35 collisions required bumper replacement
Cost of Repairing LRV Damage

$2.9M

Total eight-year cost of damages to LRT

Average Cost $11,000 / Collision
Typically returned to service in 4 to 5 days
Summary 1 – Proven Success

• Accidents are inevitable!
• Fully enclosed vehicle cab ends without sharp corners save lives
• Retracted couplers reduce penetration of motor vehicles
• Shock absorbing bumpers and easily replaceable panels reduce the cost and time vehicles are out of service
Summary 2 – Work Still Needed

• Further work needed to reduce passenger injuries due to falls during sudden stops
• Additional steps to attract the attention of “distracted” pedestrians needed
• Development of further measures to prevent pedestrians from going under the LRV needed
A special thanks is extended to those Valley Metro Rail staff without whose generous assistance this presentation would not have been possible.