Saving Lives and Reducing Costs Through Crashworthy Light Rail Vehicle Design

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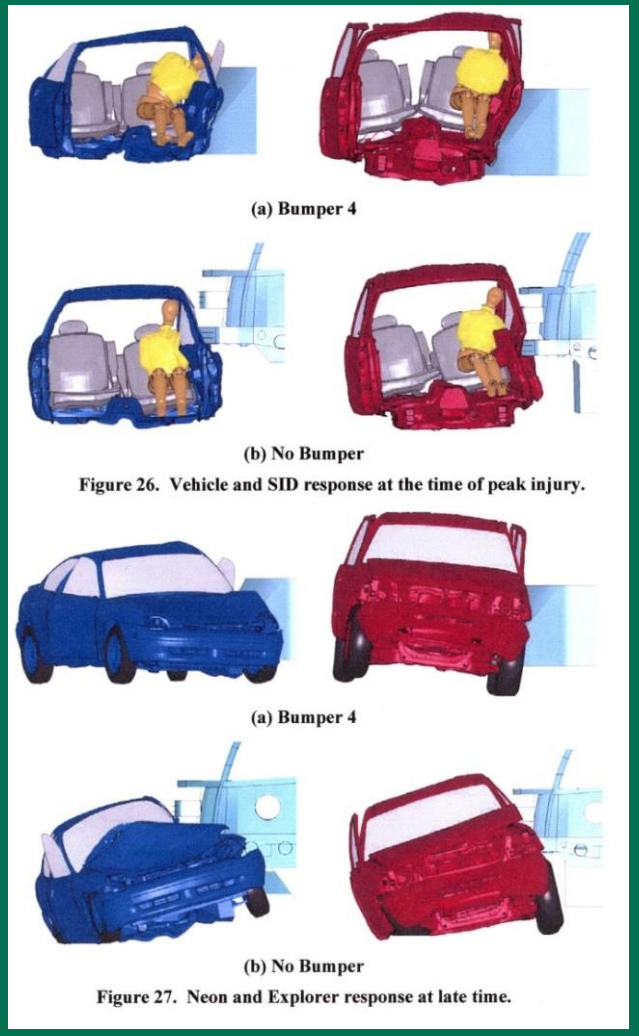
Safety Goals for Light Rail Vehicles

- 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



(a) Bumper 4

(b) No Bumper

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

(a) Bumper 4

(b) No Bumper

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

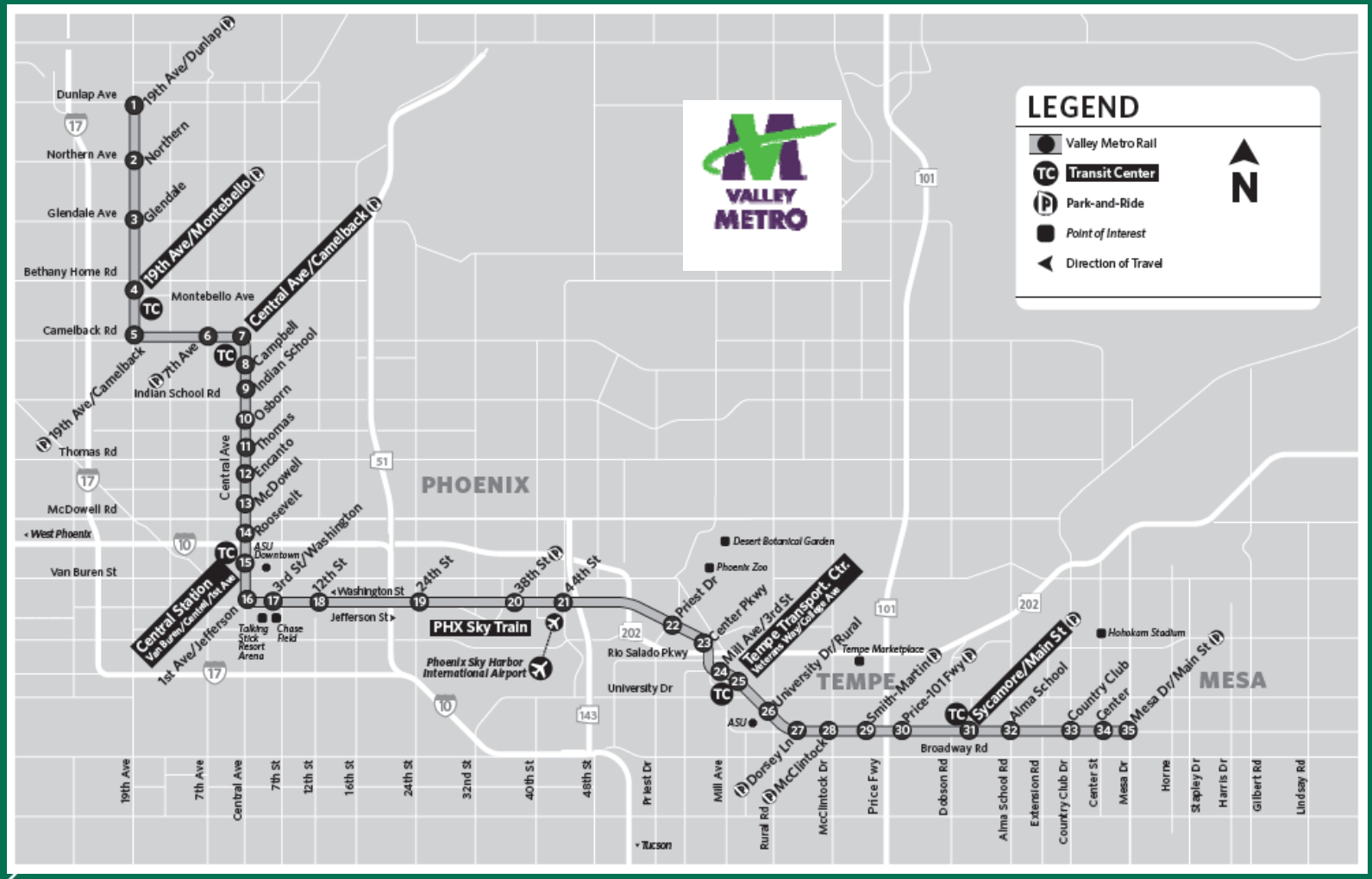
2nd Stage: Controlled Collapse Cab

Before

After

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)

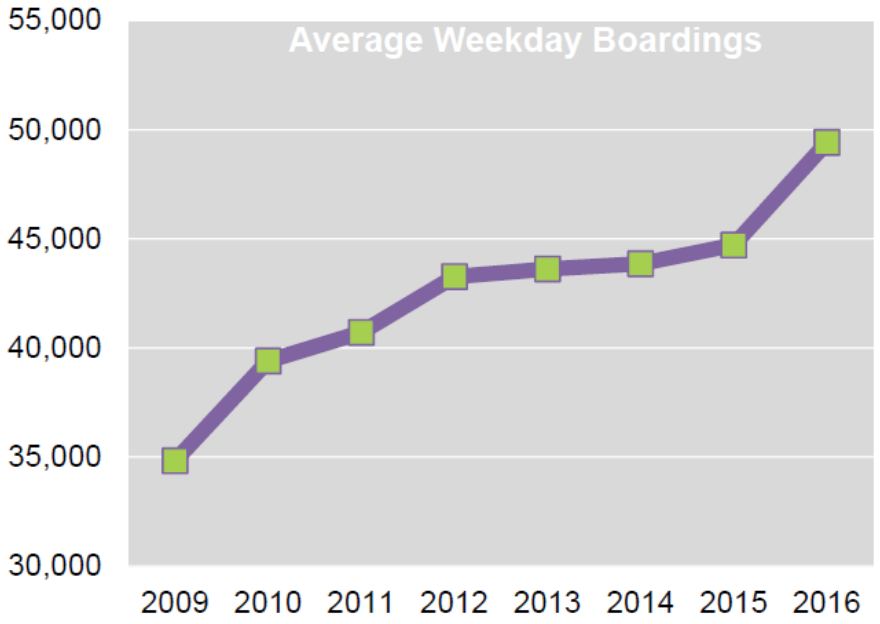
Collisions are inevitable!

Ridership Growth

42%

increase in rail boardings from 2009 to 2016

VALLEY METRO



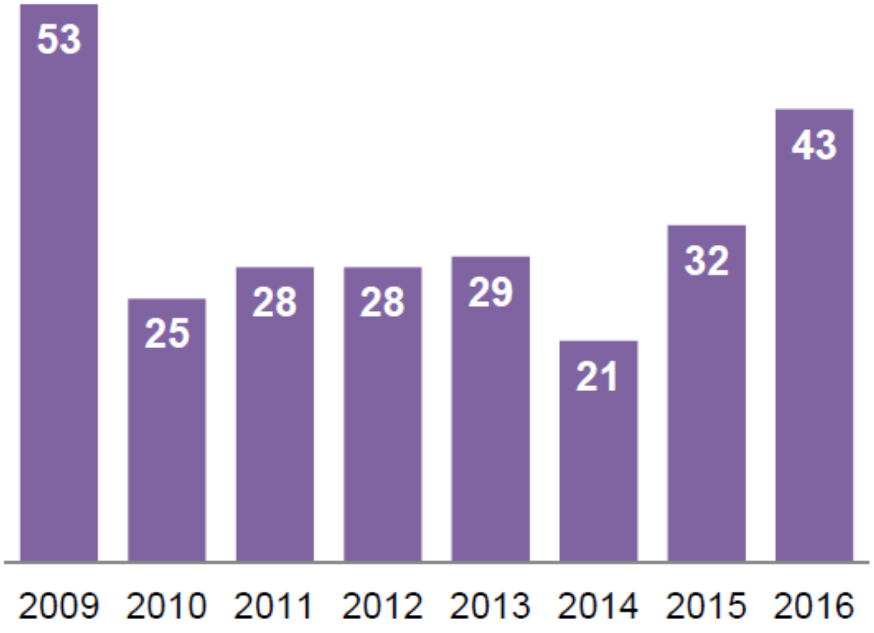
Year	Total Annual Boardings	Average Weekday
2009	11,348,343	34,828
2010	12,616,937	39,405
2011	13,161,638	40,712
2012	14,042,008	43,268
2013	14,226,293	43,619
2014	14,263,662	43,860
2015	14,759,817	44,716
2016	14,935,246	49,416

Valley Metro Rail System

Eight Years of Collisions

259

total collisions
from 2009 thru 2016



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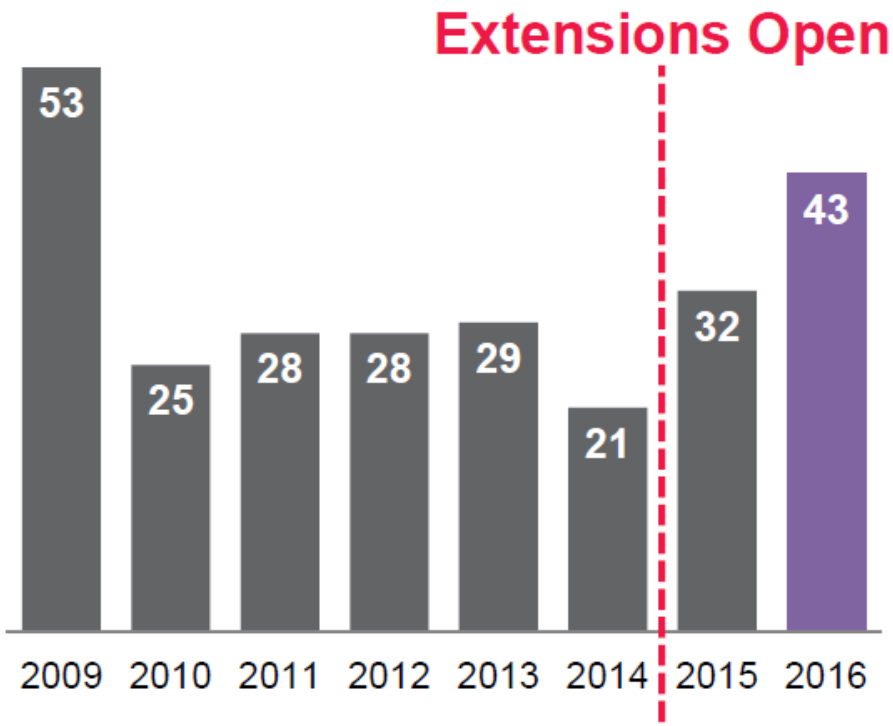
On average 2.7 Collisions / Month

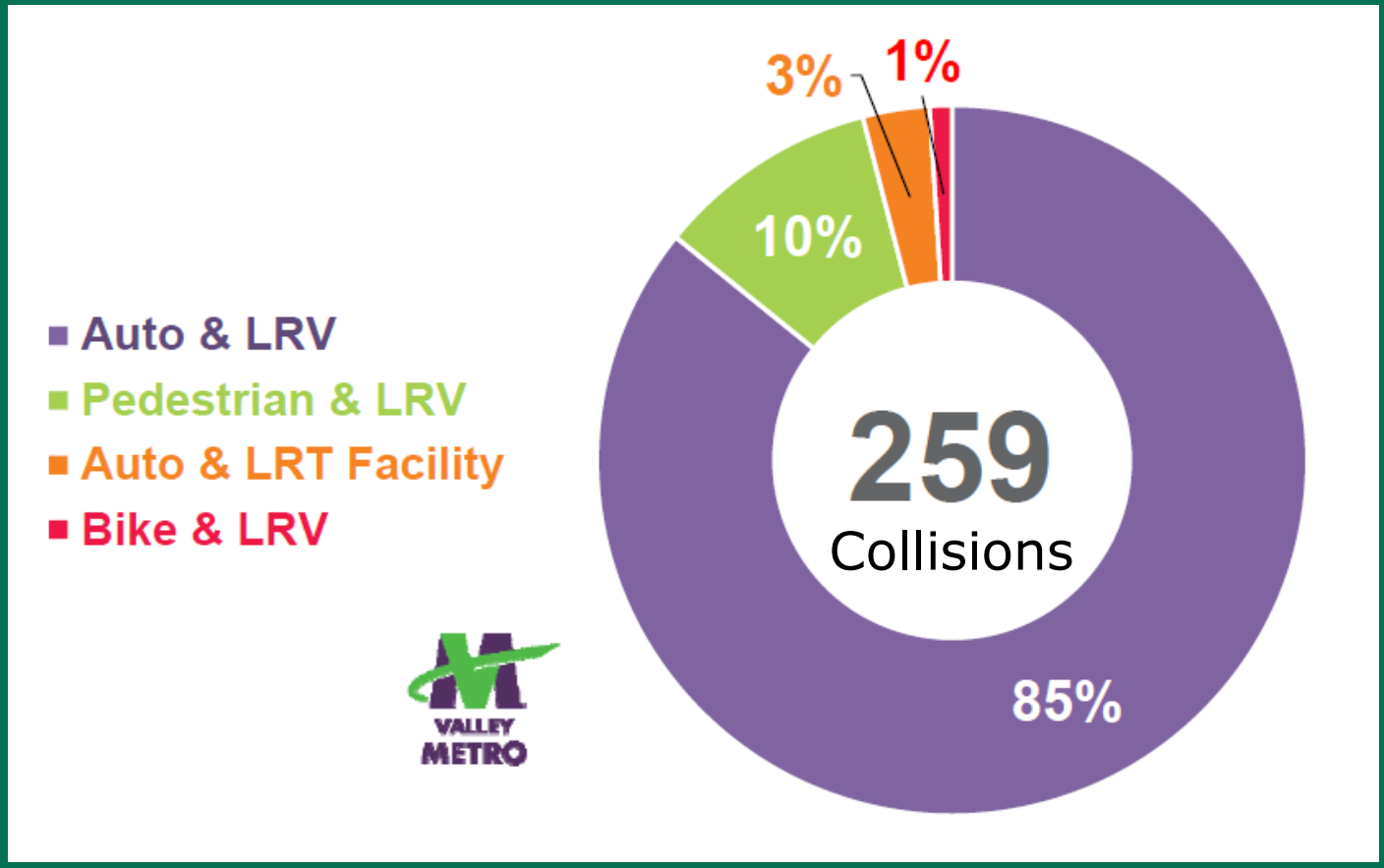
The Second Learning Curve

Possible Factors:

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



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

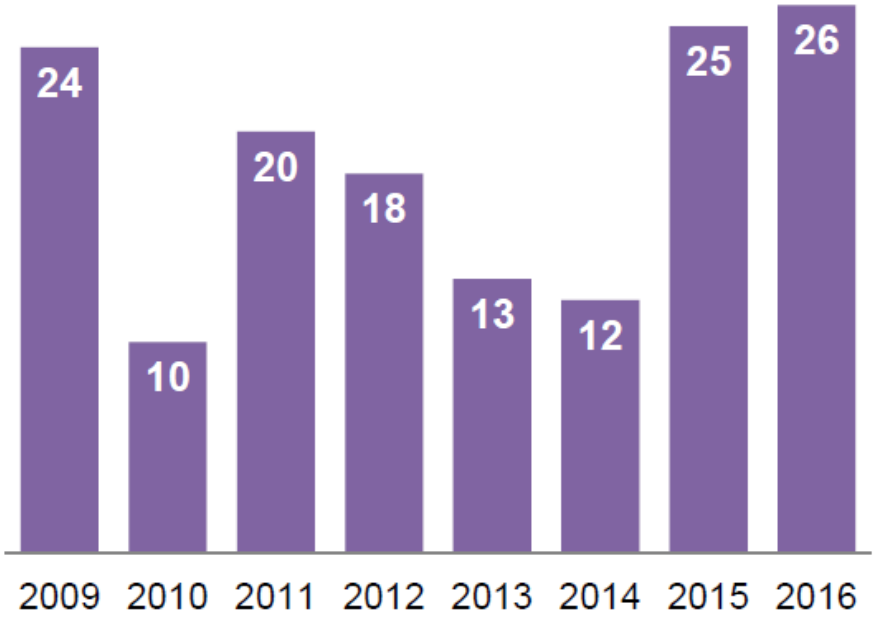
Total Persons Injured

VALLEY METRO

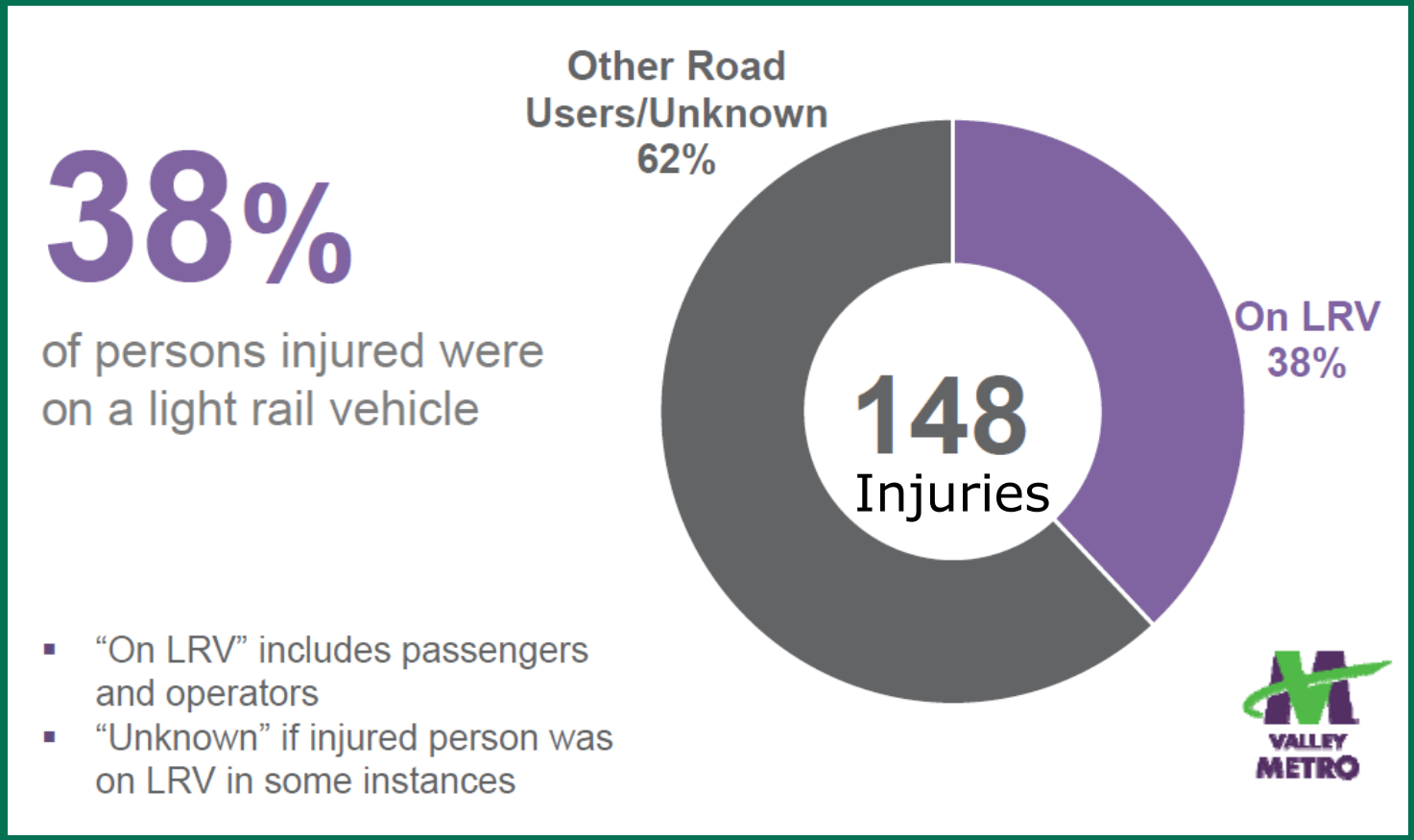
148

persons injured in eight years

Includes LRT passengers & other road users

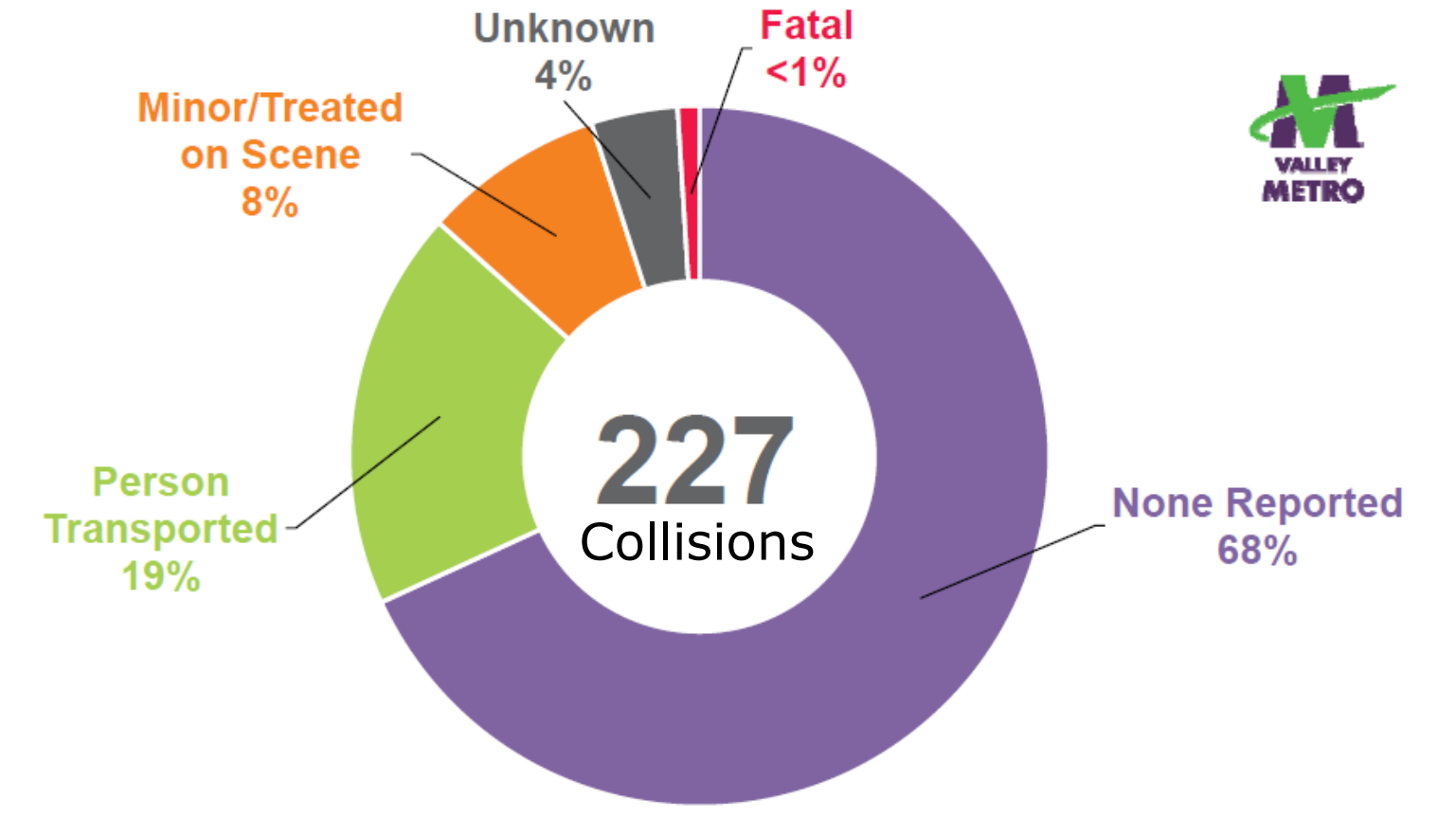


LRV Passengers Injured

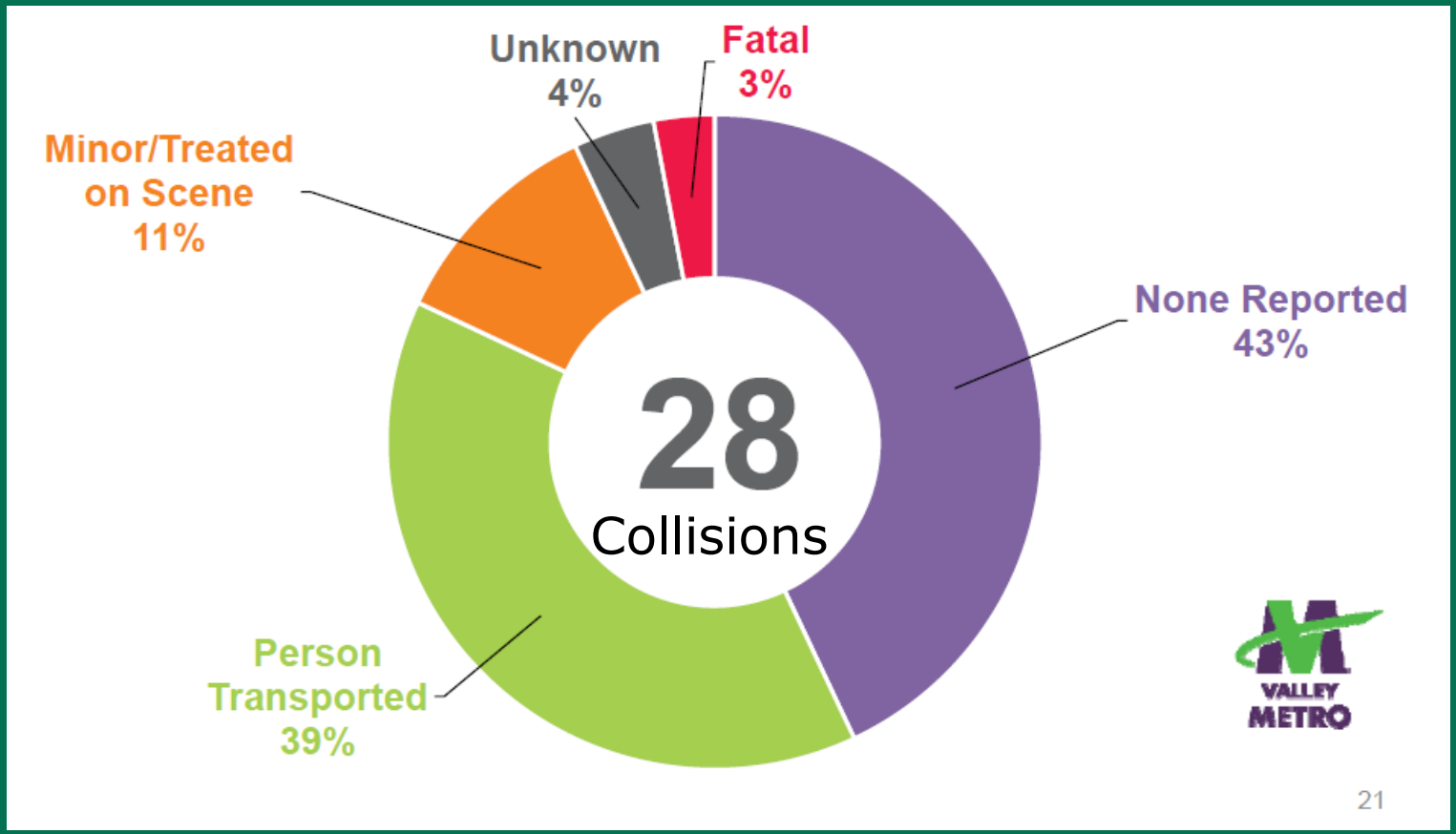


58 passengers were injured inside LRV due to fall from rapid stops, etc.

Severity of Injuries - Auto



Severity of Injuries - Pedestrians



Accident Damage

Damage Mostly Cosmetic

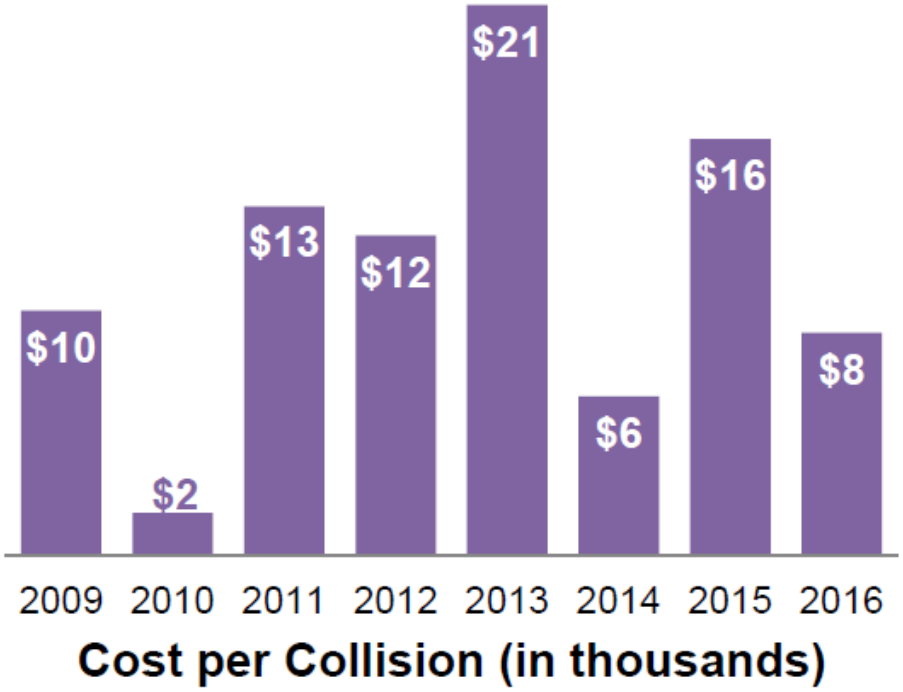
Accident Damage

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

Special Thanks

A special thanks is extended to those Valley Metro Rail staff without whose generous assistance this presentation would not have been possible