



**VRU-Proxi-11-08**

Update to Summary of Collision Landscape Analyses

September 2019

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# TRL Background



# TRL Background

## Vision

World leader in creating the future of transport and mobility, using evidence-based solutions and innovative thinking

320

engineers, scientists, psychologists, IT experts and statisticians




Providing world-leading research, technology and software solutions for surface transport modes and the related markets of automotive, motorsport, insurance and energy

## Mission

Challenge and influence our chosen markets, driving sustained reductions (ultimately to zero) in:

- Fatalities and serious injuries
- Harmful emissions
- Barriers to inclusive mobility
- Unforeseen delays
- Cost inefficiencies

1000 clients in

**145** countries

# TRL Background...delivering impactful innovation

1950's/70's

The UK Motorway network



1969

The self-driving Citroën DS19



1997

NCAP launched



2014

TRL cycle infrastructure development



2015

Gateway driverless shuttles



2018

London Smart Mobility Living Lab



1960s

Early simulator



1972

The magic roundabout, Swindon



1980's

Deflectometer



2012

London Summer Olympics



2016

Electric double decker bus



2017

HGV Truck Platooning



# Total Populations for EU28



# Analysis Approach

## Background on Collision Landscape Analysis Approach

- All vehicles categorised into Dir. 2007/46/EC categories using STATS19 data
- STATS19 variables used to define total population of casualties
- Total population values scaled to EU28 for each vehicle category and injury severity level
- Further criteria used to define target populations for each safety measure
- Target populations presented as the number of casualties per annum and monetised cost to society per annum
- Monetised cost to society figures used:
  - Fatal - €1.87million, Serious - €243,100, Slight - €18,700
- Approach provided in greater detail in VRU-Proxi-09-03 for reference

# Update to Total Population for EU28

Total annual number of VRU casualties (EU28)

Vehicle Category	Pedestrian			Cyclist			PTW			Societal Cost (€M)
	Fatal	Serious	Slight	Fatal	Serious	Slight	Fatal	Serious	Slight	
<b>M1</b>	3,600	27,549	83,758	1,005	16,833	86,001	1,939	30,768	106,274	<b>35,668.1</b>
<b>M2</b>	11	79	212	2	37	128	9	71	215	<b>96.9</b>
<b>M3</b>	173	893	2,763	47	251	1,045	43	252	845	<b>918.3</b>
<b>N1</b>	463	1,832	6,102	164	1,321	5,572	271	2,435	8,230	<b>3,409.9</b>
<b>N2</b>	55	250	687	27	217	862	38	243	706	<b>438.3</b>
<b>N3</b>	381	550	747	191	569	1,316	150	638	1,185	<b>1,839.2</b>
<b>N<sub>unknown</sub></b>	2	12	52	0	22	68	0	20	32	<b>19.4</b>
<b>Total</b>	<b>4,685</b>	<b>31,165</b>	<b>94,321</b>	<b>1,436</b>	<b>19,250</b>	<b>94,992</b>	<b>2,450</b>	<b>34,427</b>	<b>117,487</b>	<b>42,390.0</b>



# Total Population

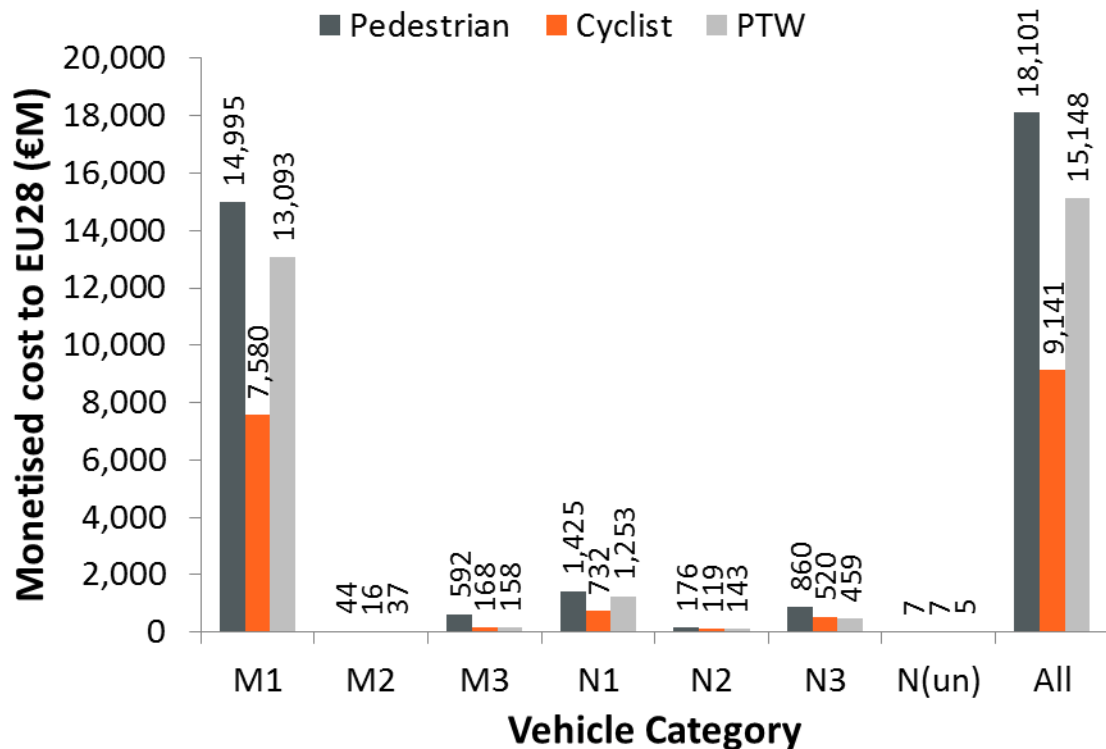
Total annual number of VRU casualties (EU28): N2/N3 Weights

Vehicle Category	Pedestrian			Cyclist			PTW			Societal Cost (€M)
	Fatal	Serious	Slight	Fatal	Serious	Slight	Fatal	Serious	Slight	
<b>N2 ≤7.5T</b>	40	164	399	16	129	491	28	168	488	<b>294.1</b>
<b>N2 &gt;7.5T</b>	2	18	39	9	17	53	8	13	34	<b>48.4</b>
<b>N2<sub>un_GVW</sub></b>	13	68	249	2	72	319	3	62	184	<b>95.8</b>
<b>N3 ≤18T</b>	64	106	163	31	140	273	20	119	214	<b>317.1</b>
<b>N3 &gt;18T</b>	269	352	375	142	316	668	110	353	631	<b>1,254.2</b>
<b>N3<sub>un_GVW</sub></b>	48	92	209	18	114	375	20	166	340	<b>267.8</b>

# Update to Total Population for EU28

## Total annual societal costs of VRU casualties (EU28)

- Total annual societal cost to EU28 of €42.4bn
- Collisions between M1 vehicles and VRUs have highest occurrence and societal costs
- Ranking of societal costs:
  - M1>N1>N3>M3>N2>M2
  - N2≤7.5T greater than N2>7.5T
  - N3>18T greater than N2≤18T
- Target populations (TP) derived from total population



# Collision Characteristics Analysis



# Collision Characteristics Analysis

## Definition of Collision Characteristics

- Key Collision Characteristics
  - Objectives - to establish which key VRU manoeuvres are most relevant to the vehicle manoeuvre/s associated with each regulation
  - Vehicle manoeuvres
    - Specific to particular regulation intention/s (e.g. reversing for reversing safety reg)
    - Split by manoeuvre where multiple manoeuvres defined in target populations
  - Vehicle impact points
    - Also specific to particular regulation intention/s and split by impact point
  - VRU manoeuvres/impact points
    - Key comparison for analysis
    - Investigated via a combination of VRU manoeuvre and VRU/vehicle impact points
    - E.g. cyclist manoeuvring alongside nearside of vehicle controlled by straight ahead manoeuvres combined with vehicle impact nearside/VRU impact offside

# Collision Characteristics Analysis

## Target Population Definitions

- Target population:
  - “The total number of fatalities and/or injured casualties that a particular safety measure is specifically designed to try to prevent each year”
- Target populations previously calculated for each safety measure:
  - Target populations defined using vehicle/VRU manoeuvres, vehicle/VRU impact points and contributory factors from STATS19 (GB)
  - Scaled to EU28 – based on scaling factors developed from ACEA data
  - Defined in VRU-Proxi-09-03
- Focus on vulnerable road users injured in collisions with vehicles performing low speed manoeuvres
  - VRU types: pedestrians, cyclists, PTWs
  - Vehicle categories: M1, M2, M3, N1, N2, N3
  - Outcomes: monetary value to society – combining injury severities to one simple metric

# Blind-Spot Information System (BSIS)



# Target Populations: BSIS

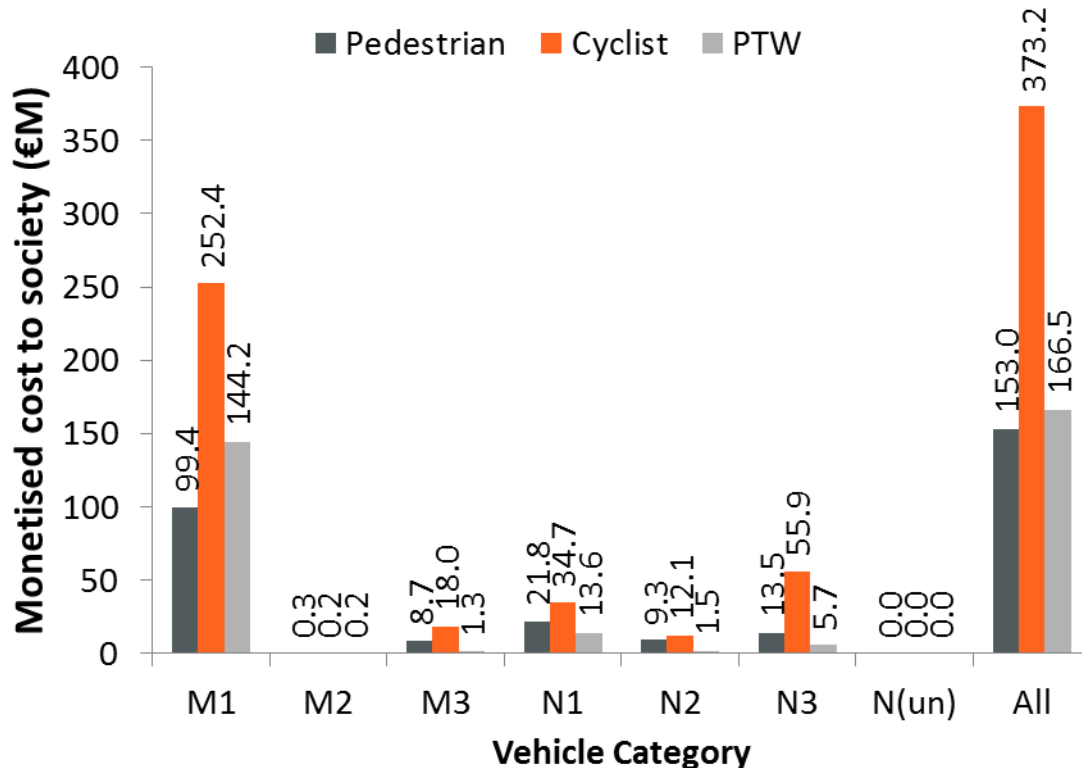
## BSIS Target Population Definitions

Pedestrian			Cyclist/PTW				Contributory Factors
Vehicle Manoeuvre	Vehicle Impact	VRU Manoeuvre	Vehicle Manoeuvre	Vehicle Impact	VRU Manoeuvre	VRU Impact	
Nearside turn	Nearside Front	Crossing from driver's n/s In carriageway, not crossing Walking along back to traffic Walking along facing traffic	Nearside turn	Nearside Front	Going ahead LH bend/RH bend/other Moving off Overtaking on n/s Slowing or stopping Left turn Waiting to go ahead Waiting to turn left/right	Offside	Driver Failed To Look Properly (405)
			<b>OR</b>		Going ahead LH bend/RH bend/other Overtaking moving vehicle on its o/s Changing lane to left		

# EU28 Target Populations: BSIS

## Total Annual Societal Costs of BSIS VRU Casualties (EU28)

- BSIS target population
- Total annual societal cost to EU28 of €693M
- Collisions between M1 vehicles and VRUs have highest societal costs
- Cyclists most affected casualty
- Ranking of societal costs:
  - M1>N3>N1>M3>N2>M2

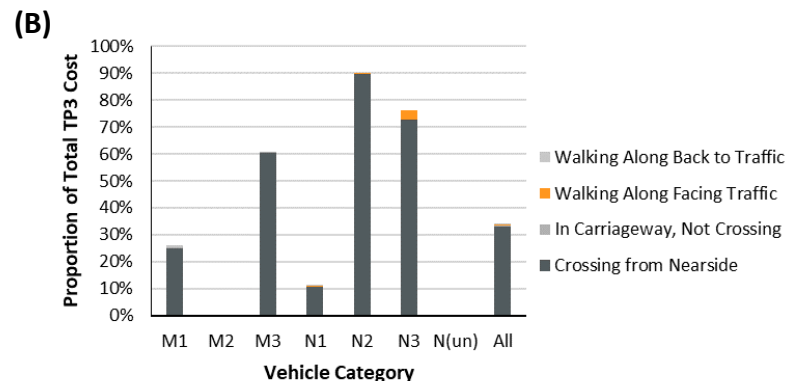
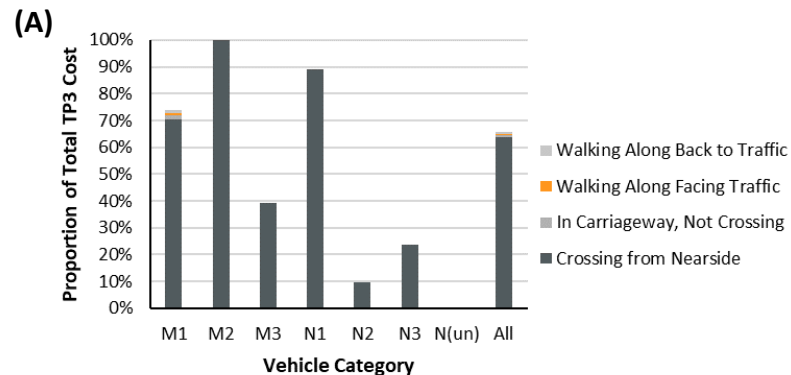




# Key Collision Characteristics: BSIS

## Key Vehicle and VRU Manoeuvres Characterising Pedestrian Collisions

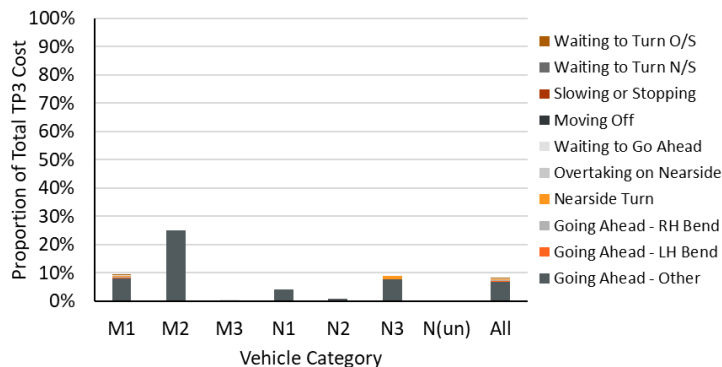
- Comparison of pedestrian manoeuvres for:
  - A. Nearside turn – pedestrian strikes front
  - B. Nearside turn – pedestrian strikes nearside
- Key pedestrian manoeuvres:
  - Crossing from nearside
  - Other manoeuvres negligible
- Bus manoeuvres:
  - Heavier vehicles (M3/N2/N3) associated with nearside impact points
  - Lighter vehicles (M1/N1) associated with frontal impact points



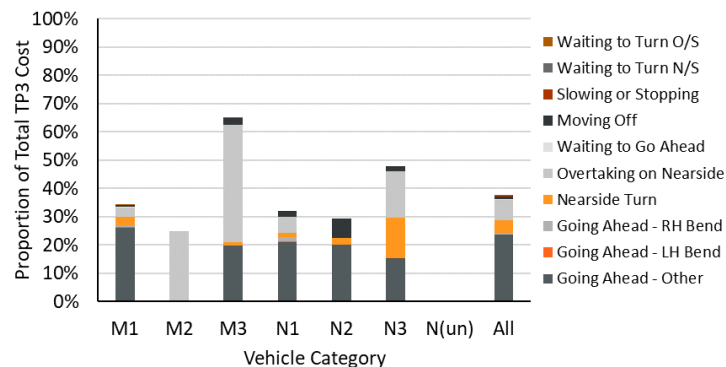
# Key Collision Characteristics: BSIS

## Key Vehicle and VRU Manoeuvres Characterising Cyclist Collisions

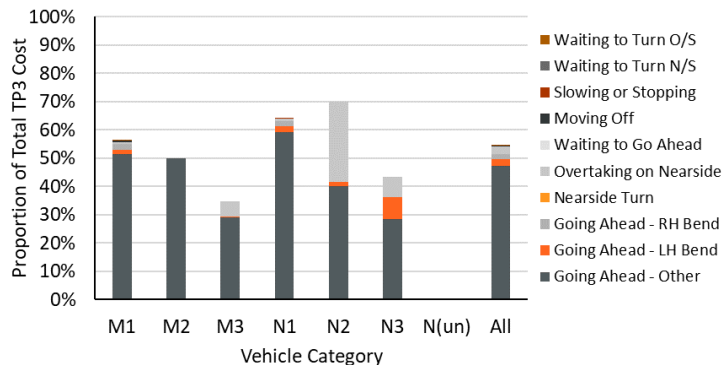
### Nearside Turn – Frontal Impact



### Nearside Turn – Nearside Impact



### No Turn – Nearside Impact



# Key Collision Characteristics: BSIS

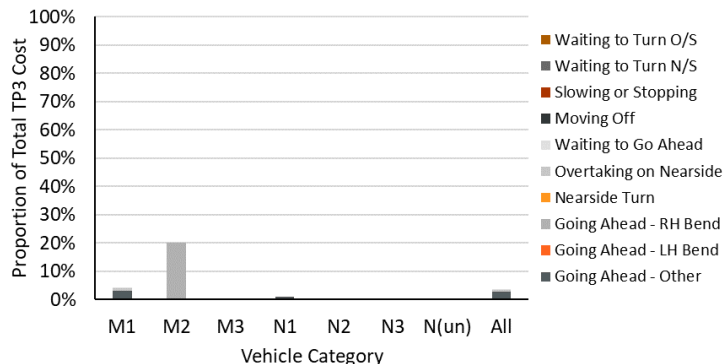
## Key Vehicle and VRU Manoeuvres Characterising Cyclist Collisions

- Comparison of cyclist manoeuvres for:
  - Nearside turn – cyclist strikes front
  - Nearside turn – cyclist strikes nearside
  - No turn – cyclist strikes nearside
- Key cyclist manoeuvres:
  - Going Ahead Other (RH bend/LH bend) most important – ~80% of all casualty costs
    - Particularly important for “No Turn” scenarios, where cyclist is being overtaken
  - Overtaking on nearside (i.e. undertaking), nearside turn with vehicle also important
- Bus manoeuvres:
  - Heavier vehicles (M3/N3) have greater proportion of nearside turn collisions
  - Lighter vehicles (M1/N1/N2) have greater proportion of no turn collisions

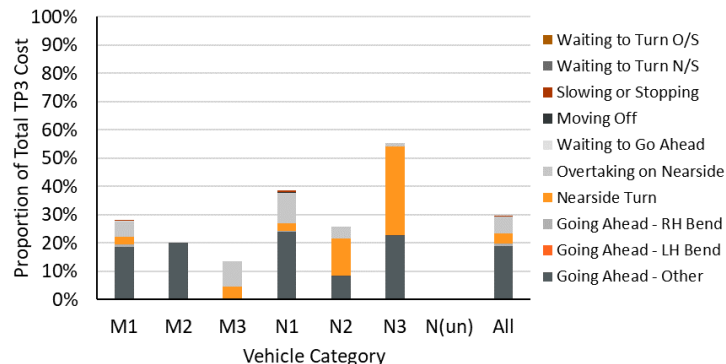
# Key Collision Characteristics: BSIS

## Key Vehicle and VRU Manoeuvres Characterising PTW Collisions

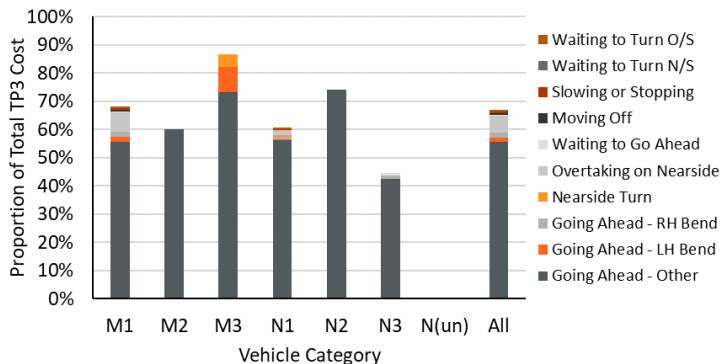
### Nearside Turn – Frontal Impact



### Nearside Turn – Nearside Impact



### No Turn – Nearside Impact



# Key Collision Characteristics: BSIS

## Key Vehicle and VRU Manoeuvres Characterising PTW Collisions

- Comparison of PTW manoeuvres for:
  - Nearside turn – PTW strikes front
  - Nearside turn – PTW strikes nearside
  - No turn – PTW strikes nearside
- Key PTW manoeuvres:
  - Going Ahead Other (RH bend/LH bend) most important – ~80% of all casualty costs
    - Particularly important for “No Turn” scenarios, where PTW is overtaken/undertaking
  - Overtaking on nearside (i.e. undertaking), nearside turn with vehicles also important
- Bus manoeuvres:
  - N3 vehicles have greater proportion of nearside turn collisions
  - Lighter vehicles (M1/M3/N1/N2) have greater proportion of no turn collisions

# Key Collision Characteristics: BSIS

## Summary of Key BSIS Collision Characteristics

- Collision characteristics for pedestrian casualties specific to BSIS
  - Pedestrian crossing from the nearside
  - Impacts to nearside of heavier vehicles (M3/N2/N3) and front of lighter vehicles
- Collision characteristics for cyclist casualties specific to BSIS
  - Cyclists primarily travelling straight ahead (i.e. no turn), being overtaken by vehicles
    - Significant cyclist undertaking and cyclist turning with vehicle for heavier vehicles
  - Heavier vehicles (M3/N3) involved in greater proportion of nearside turn collisions, whilst lighter vehicles involved in greater proportion of overtaking collisions
- Collision characteristics for PTW casualties specific to BSIS
  - PTWs primarily travelling straight ahead (i.e. no turn), being overtaken by vehicles
    - Significant PTW undertaking and PTW turning with vehicle for heavier vehicles
  - N3 vehicles involved in greater proportion of nearside turn collisions, whilst all other vehicles involved in greater proportion of overtaking collisions

# Reversing Camera & Detection System (REV)



# Target Populations: REV

## REV Target Population Definitions

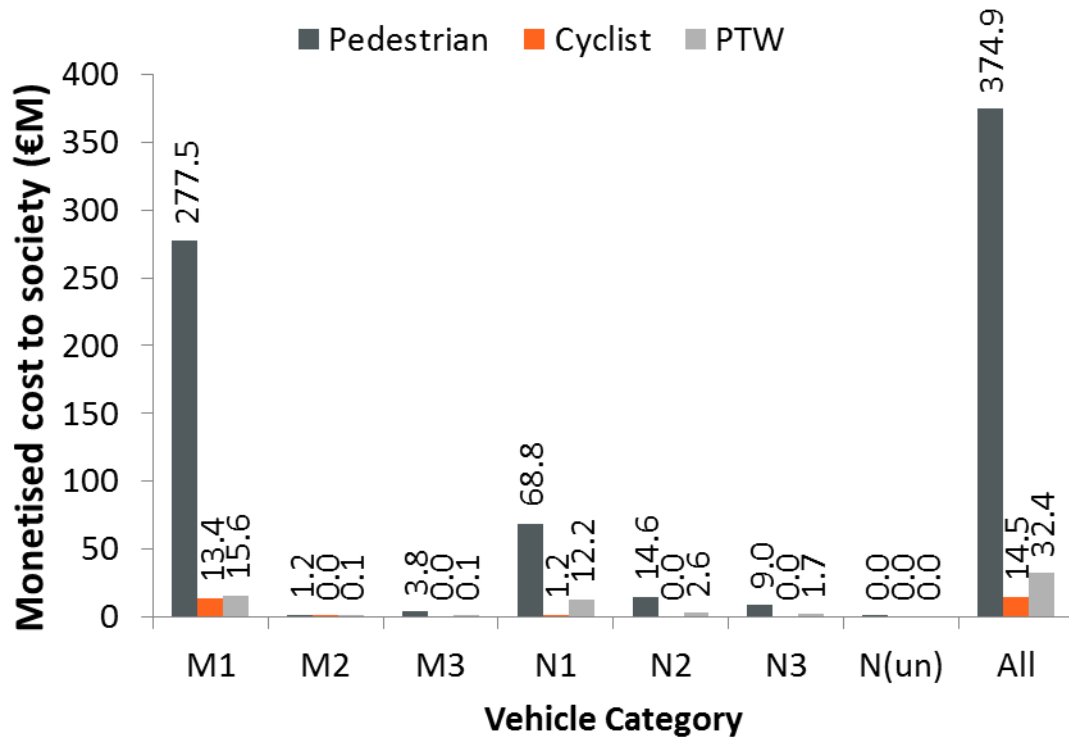
Pedestrian			Cyclist/PTW				Contributory Factors
Vehicle Manoeuvre	Vehicle Impact	VRU Manoeuvre	Vehicle Manoeuvre	Vehicle Impact	VRU Manoeuvre	VRU Impact	
Reversing	Rear	Crossing from driver's n/s Crossing from driver's o/s In carriageway, not crossing Walking along back to traffic Walking along facing traffic	Reversing	Rear	Moving off Slowing or stopping Waiting to go ahead Waiting to turn left/right	-	Driver Failed To Look Properly (405) OR Vehicle Blind Spot (710)
			<b>OR</b>				



# EU28 Target Populations: REV

## Total Annual Societal Costs of REV VRU Casualties (EU28)

- REV target population
- Total annual societal cost to EU28 of €422M (for on-road only)
- Collisions between M1 vehicles and VRUs have highest societal costs
- Pedestrians most affected casualty
- Ranking of societal costs:
  - M1>N1>N2>N3>M3>M2

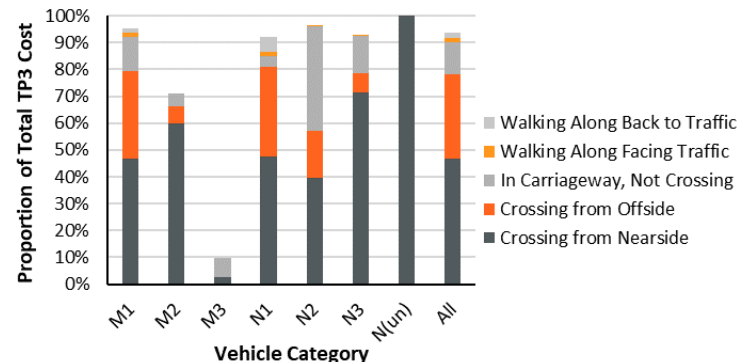


# Key Collision Characteristics: REV

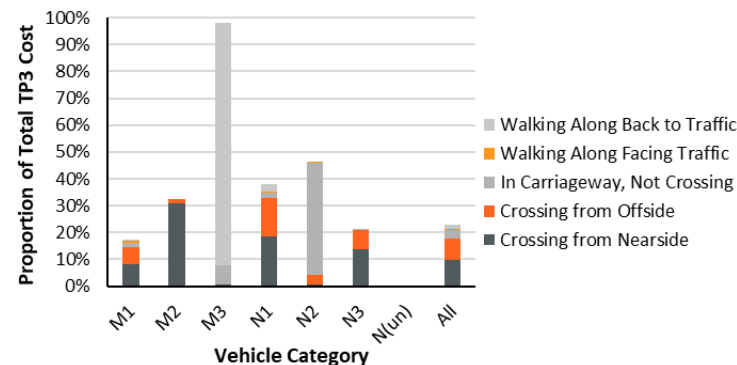
## Key Vehicle and VRU Manoeuvres Characterising Pedestrian Collisions

- Comparison of pedestrian manoeuvres for:
  - A. Reversing – driver failed to look properly
  - B. Reversing – vehicle blind spot
  - C. Reversing – both contributory factors
  - D. Reversing – either contributory factor
- Key pedestrian manoeuvres:
  - Crossing from nearside/offside
  - In carriageway – relatively small proportion
- Vehicle categories:
  - M3 vehicle collisions primarily associated with vehicle blind spots – CMS needed?
  - Other vehicles dominated by driver failing to look properly – information systems needed?

(A)



(B)

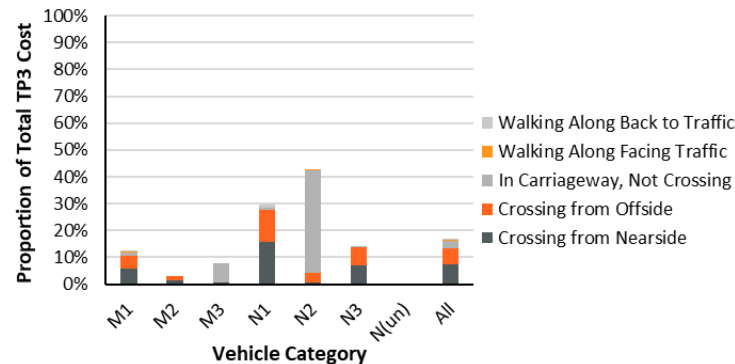


# Key Collision Characteristics: REV

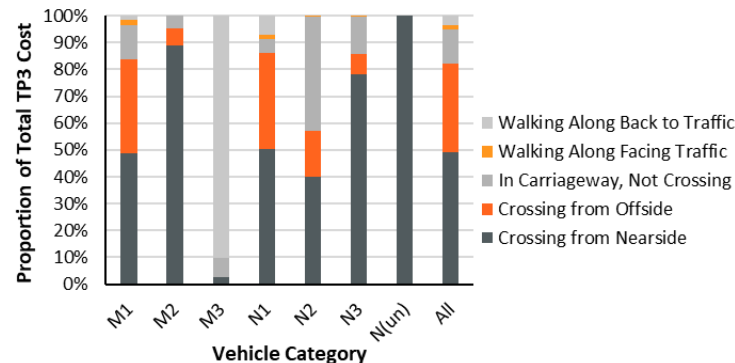
## Key Vehicle and VRU Manoeuvres Characterising Pedestrian Collisions

- Comparison of pedestrian manoeuvres for:
  - A. Reversing – driver failed to look properly
  - B. Reversing – vehicle blind spot
  - C. Reversing – both contributory factors
  - D. Reversing – either contributory factor
- Key pedestrian manoeuvres:
  - Crossing from nearside/offside
  - In carriageway – relatively small proportion
- Vehicle categories:
  - M3 vehicle collisions primarily associated with vehicle blind spots – CMS needed?
  - Other vehicles dominated by driver failing to look properly – information systems needed?

(C)



(D)



# Moving-Off Information System (MOIS)



# Target Populations: MOIS

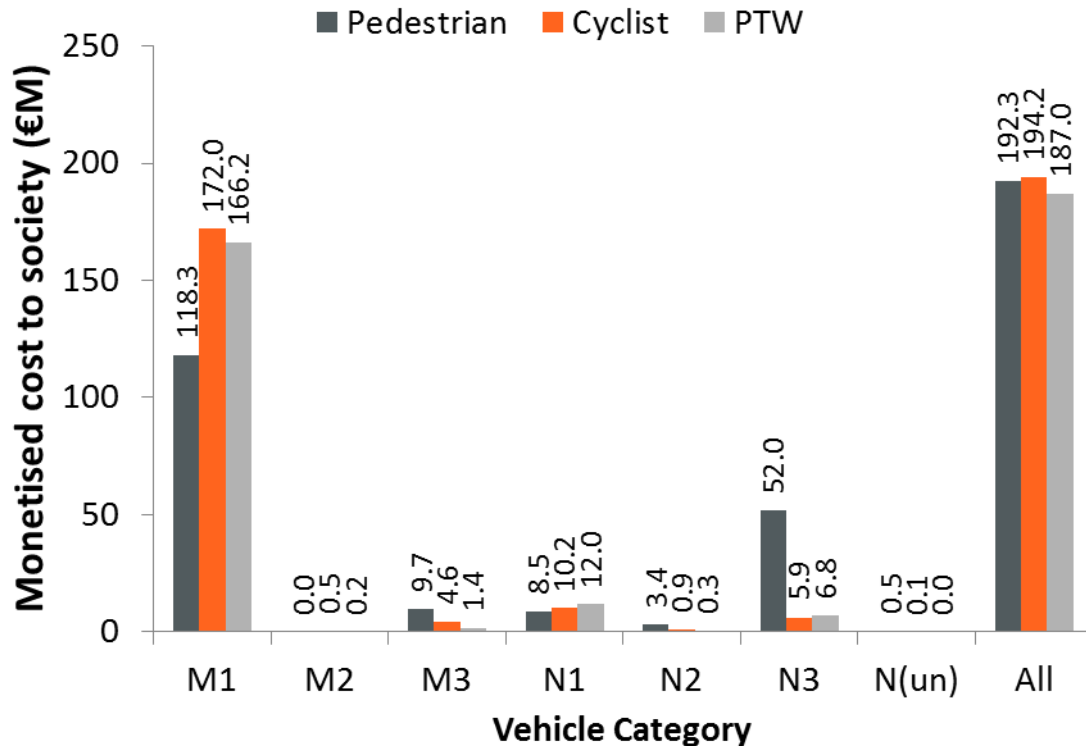
## MOIS Target Population Definitions

Pedestrian			Cyclist/PTW				Contributory Factors
Vehicle Manoeuvre	Vehicle Impact	VRU Manoeuvre	Vehicle Manoeuvre	Vehicle Impact	VRU Manoeuvre	VRU Impact	
Moving off Slowing or stopping	Front	Crossing from driver's n/s Crossing from driver's o/s In carriageway, not crossing Walking along back to traffic Walking along facing traffic	Moving off Slowing or stopping	Front	Moving off Slowing or stopping Waiting to go ahead Waiting to turn left/right	-	Driver Failed To Look Properly (405)
			<b>OR</b>				
			Moving off Slowing or stopping	Front	Going ahead LH bend/RH bend/other	Offside Nearside	

# EU28 Target Populations: MOIS

## Total Annual Societal Costs of MOIS VRU Casualties (EU28)

- MOIS target population
- Total annual societal cost to EU28 of €573M
- Collisions between M1 vehicles and VRUs have highest societal costs
- Equal importance for all VRU casualty types
  - Pedestrians affected for N3/M3
  - Cyclists/PTW affected for M1/N1
- Ranking of societal costs:
  - M1>N3>N1>M3>N2>M2

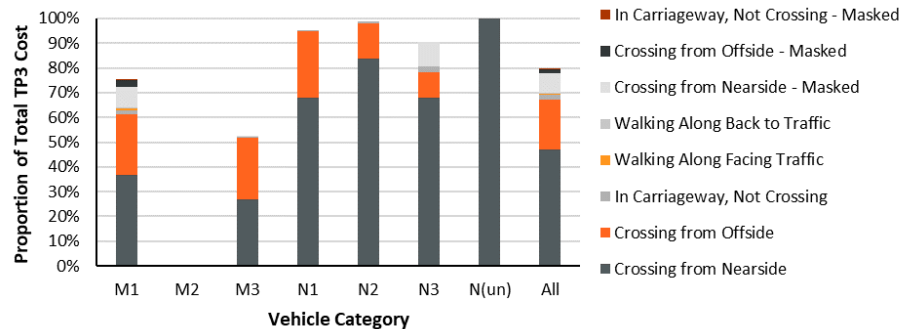


# Key Collision Characteristics: MOIS

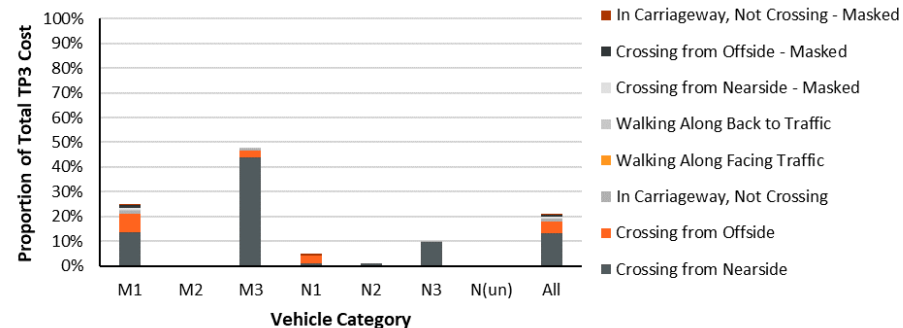
## Key Vehicle and VRU Manoeuvres Characterising Pedestrian Collisions

- Comparison of pedestrian manoeuvres for:
  - A. Moving off collisions
  - B. Slowing/stopping collisions
- Key pedestrian manoeuvres:
  - Crossing from nearside/offside
  - Crossing from nearside while masked by another vehicle also significant
  - In carriageway - negligible
- Bus manoeuvres:
  - M3 vehicles have a greater proportion of slowing/stopping – bus stops?

(A)



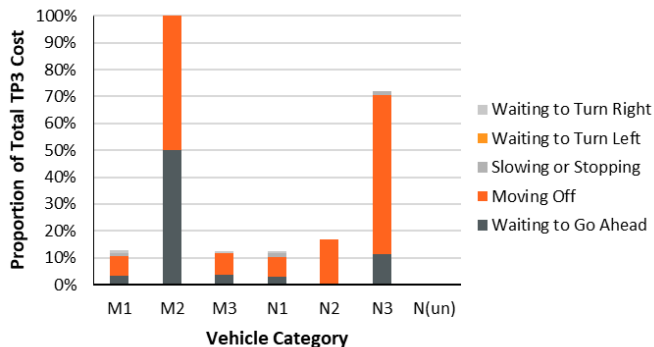
(B)



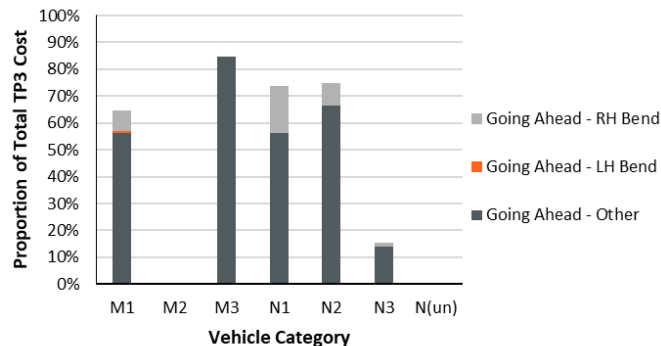
# Key Collision Characteristics: MOIS

## Key Vehicle and VRU Manoeuvres Characterising Cyclist Collisions

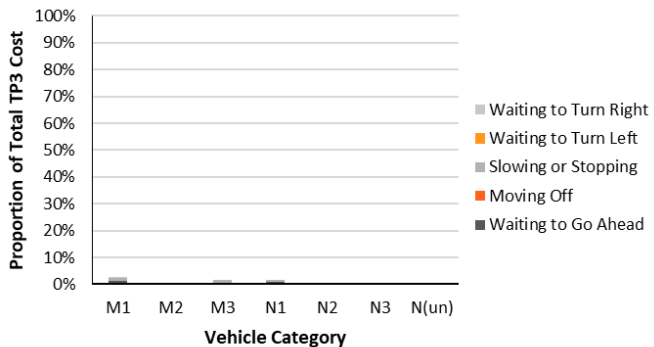
### Moving Off – Cyclist Not Crossing



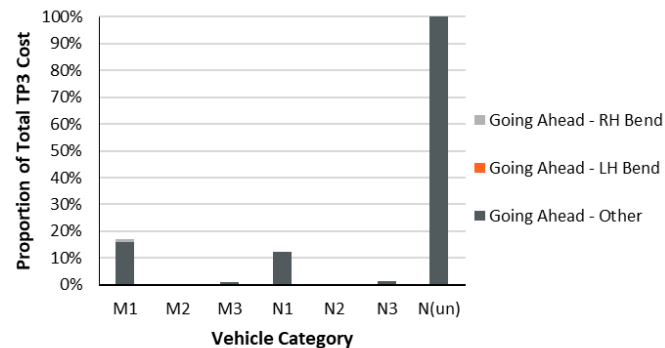
### Moving Off – Cyclist Crossing from Offside



### Slowing/Stopping – Cyclist Not Crossing



### Moving Off – Cyclist Crossing from Nearside





# Key Collision Characteristics: MOIS

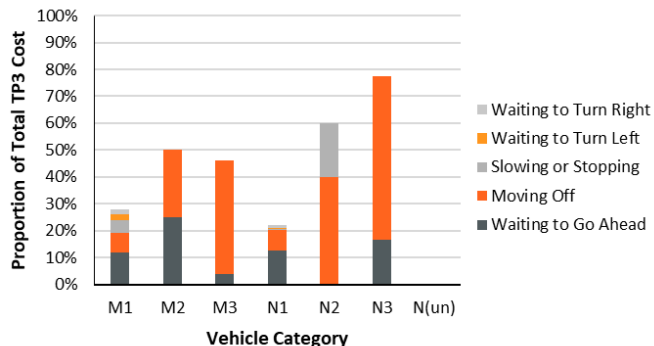
## Key Vehicle and VRU Manoeuvres Characterising Cyclist Collisions

- Comparison of cyclist manoeuvres for:
  - Moving off – cyclist not crossing
  - Slowing/stopping – cyclist not crossing
  - Moving off – cyclist crossing from nearside
  - Moving off – cyclist crossing from offside
- Key cyclist manoeuvres:
  - Cyclist crossing from offside most important for M1/M3/N1/N2 vehicles
    - Representing a vehicle moving off at a junction where the cyclist crosses the vehicle path
  - Cyclist not crossing most important for N3 vehicles – cyclist waiting/also moving off
    - Representing a vehicle moving off where the cyclist is travelling/located directly in the vehicle path
- Bus manoeuvres:
  - Few collisions occur while vehicles slowing/stopping

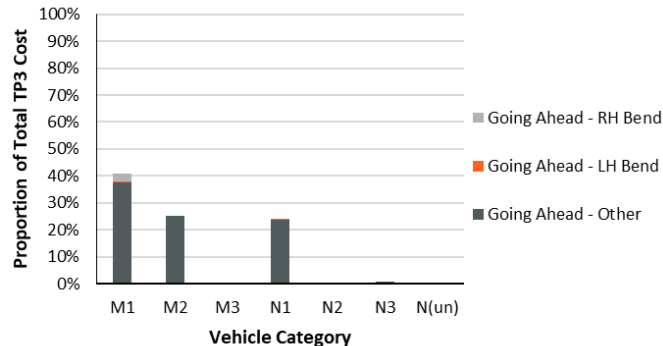
# Key Collision Characteristics: MOIS

## Key Vehicle and VRU Manoeuvres Characterising PTW Collisions

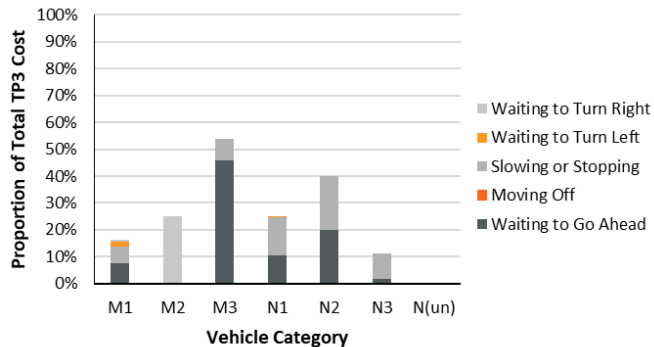
### Moving Off – PTW Not Crossing



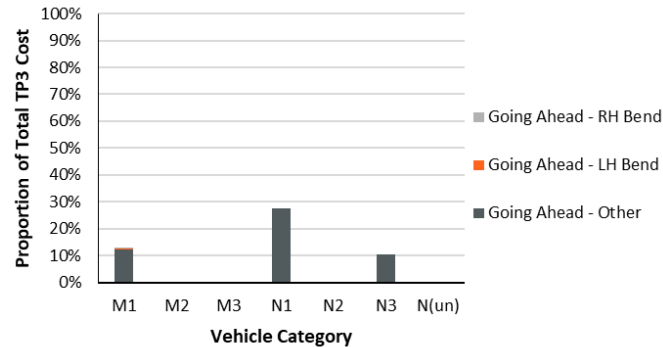
### Moving Off – PTW Crossing from Offside



### Slowing/Stopping – PTW Not Crossing



### Moving Off – PTW Crossing from Nearside



# Key Collision Characteristics: MOIS

## Key Vehicle and VRU Manoeuvres Characterising PTW Collisions

- Comparison of PTW manoeuvres for:
  - Moving off – PTW not crossing
  - Slowing/stopping – PTW not crossing
  - Moving off – PTW crossing from nearside
  - Moving off – PTW crossing from offside
- Key PTW manoeuvres:
  - PTW not crossing important for all vehicles
    - PTW may be waiting, moving off, slowing/stopping
    - More important for heavier (M3/N2/N3) vehicles
  - PTW crossing from offside important for lighter (M1/N1) vehicles
- Bus manoeuvres:
  - Slowing/stopping collisions primarily involved PTW not crossing collision scenarios
  - Moving off collisions are the principle vehicle manoeuvre, for all but M3 vehicles

# Key Collision Characteristics: MOIS

## Summary of Key MOIS Collision Characteristics

- Collision characteristics for pedestrian casualties specific to MOIS
  - Pedestrian primarily crossing from the nearside, but also offside
  - Pedestrians may also be masked by other vehicles
- Collision characteristics for cyclist casualties specific to MOIS
  - Cyclists crossing from offside most important for M1/M3/N1/N2 vehicles
    - Cyclists crossing at junction as vehicle moves off
  - Cyclist not crossing (moving off/waiting) most important for N3 vehicles
    - Cyclists travelling/located within the vehicle path as vehicle moves off
- Collision characteristics for PTW casualties specific to BSIS
  - PTW not crossing (moving off/waiting) important for all vehicles
    - Particularly for heavier (M3/N2/N3) vehicles
    - For both moving off and slowing/stopping vehicle manoeuvres
  - PTW crossing from offside most important for lighter (M1/N1) vehicles

# Direct Vision (DIR)



# Target Populations: DIR

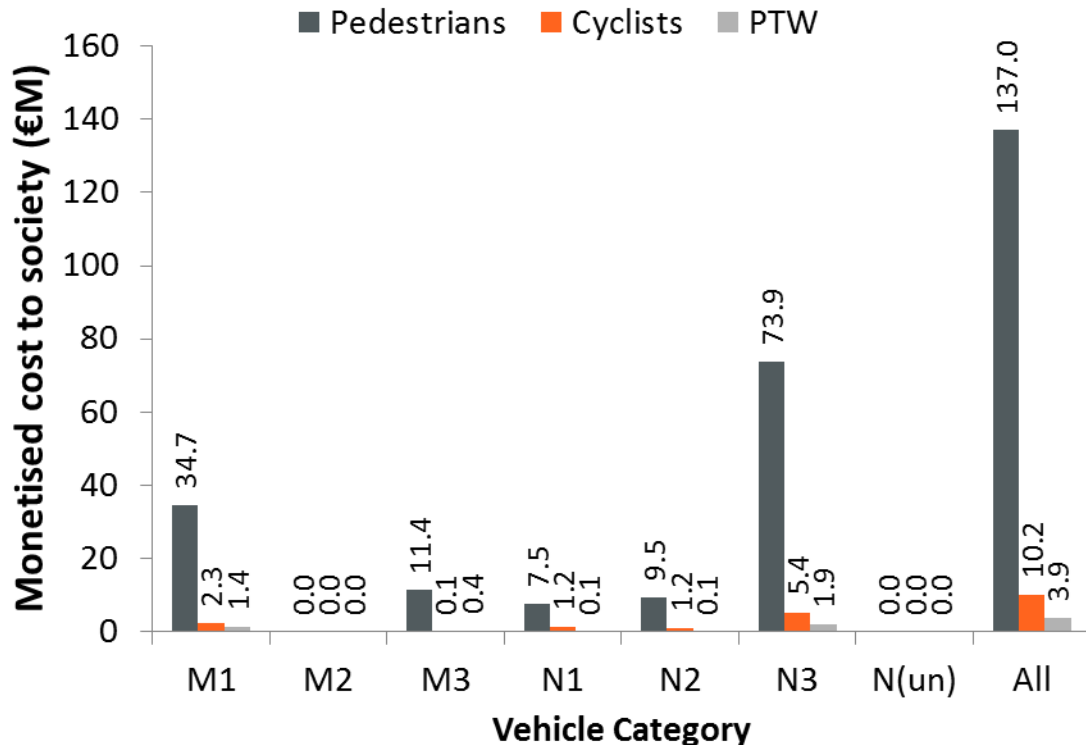
## DIR Target Population Definitions

Pedestrian			Cyclist/PTW				Contributory Factors		
Vehicle Manoeuvre	Vehicle Impact	VRU Manoeuvre	Vehicle Manoeuvre	Vehicle Impact	VRU Manoeuvre	VRU Impact		Cab-Only Impacts Correction Factor	
Moving off Slowing or stopping Nearside turn Offside turn	Front Nearside Offside	Crossing from driver's n/s Crossing from driver's o/s In carriageway, not crossing Walking along back to traffic Walking along facing traffic	Moving off Slowing or stopping	Front	Moving off Slowing or stopping Waiting to go ahead Waiting to turn left/right	-	-	Vehicle Blind Spot (710)	
			<b>OR</b>						
			Nearside turn	Nearside	Left turn Moving off Slowing or stopping Waiting to go ahead Waiting to turn left/right	Offside	0.7 (M2/M3/N2/N3)		
			<b>OR</b>						
			Offside turn	Offside	Right turn Moving off Slowing or stopping Waiting to go ahead Waiting to turn left/right	Nearside	0.7 (M2/M3/N2/N3)		

# EU28 Target Populations: DIR

## Total Annual Societal Costs of DIR VRU Casualties (EU28)

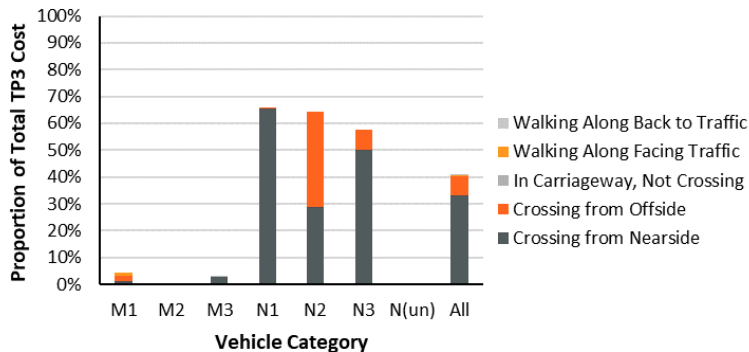
- DIR target population
- Total annual societal cost to EU28 of €151M
- Collisions between N3 vehicles and VRUs have highest societal costs
- Pedestrians most affected casualty
- Ranking of societal costs:
  - N3>M1>M3>N2>N1>M2



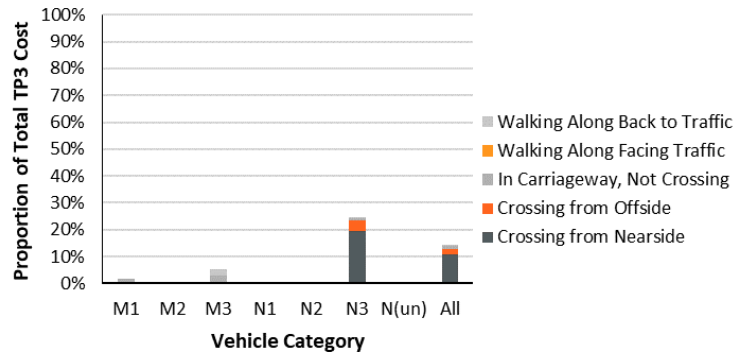
# Key Collision Characteristics: DIR

## Key Vehicle and VRU Manoeuvres Characterising Pedestrian Collisions

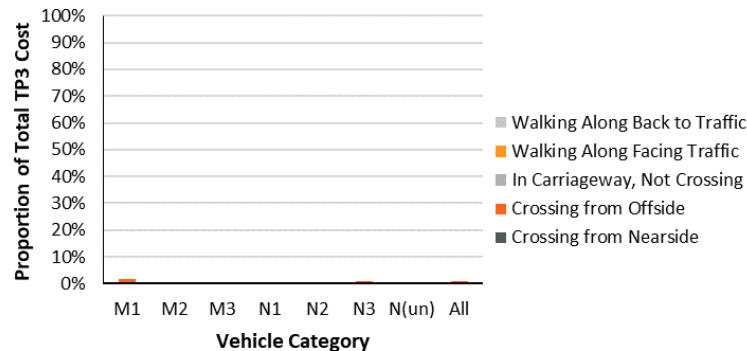
### Moving-Off – Frontal Impact



### Moving Off – Nearside Impact



### Moving Off – Offside Impact

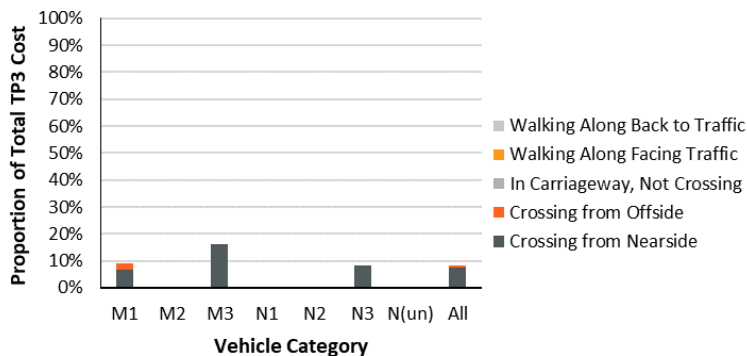




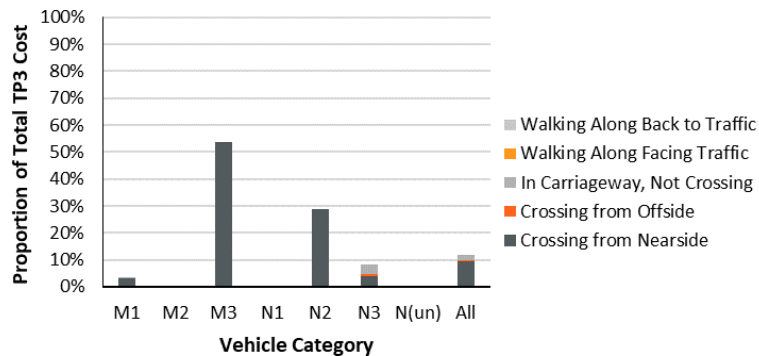
# Key Collision Characteristics: DIR

## Key Vehicle and VRU Manoeuvres Characterising Pedestrian Collisions

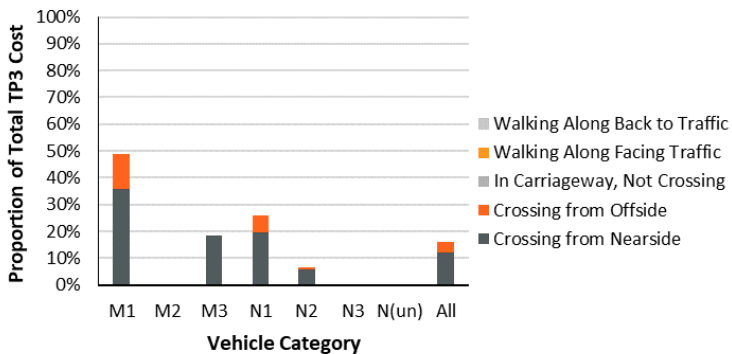
### Nearside Turn – Frontal Impact



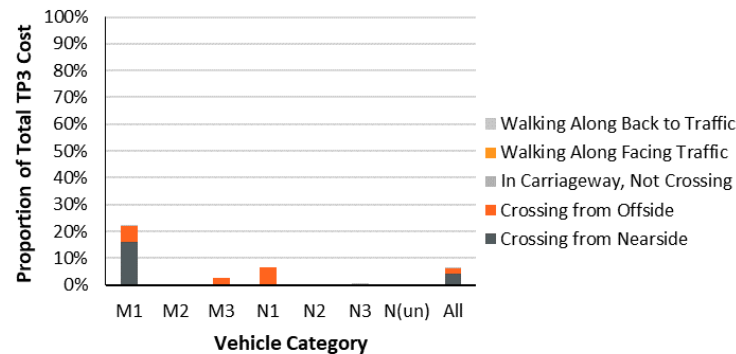
### Nearside Turn – Nearside Impact



### Offside Turn – Frontal Impact



### Offside Turn – Offside Impact



# Key Collision Characteristics: DIR

## Key Vehicle and VRU Manoeuvres Characterising Pedestrian Collisions

- Comparison of pedestrian manoeuvres for:
  - Moving off – pedestrian strikes front/nearside/offside
  - Nearside turn – pedestrian strikes front/nearside
  - Offside turn – pedestrian strikes front/offside
- Key pedestrian manoeuvres:
  - Crossing from nearside in majority of key collision scenarios
    - Consistent for all vehicle categories when considered across all collision scenarios
- Bus manoeuvres:
  - Moving off manoeuvre important for N category vehicles
  - M1 vehicles associated with offside turn collisions associated with vehicle blind spots – related to blind spots created by offside A/B pillars?
  - M3 vehicles associated with nearside turn collision associated with vehicle blind spots – related to blind spots created by A-Pillar, door frame and driver cab screen interaction

An aerial photograph of a city street intersection. The street is paved with grey asphalt and features several zebra crossings with white stripes. Several pedestrians are visible, some walking across the crossings. The scene is captured from a high angle, looking down on the street.

## Questions?

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