Applications of ITS Technologies for Safety for Vulnerable Road Users

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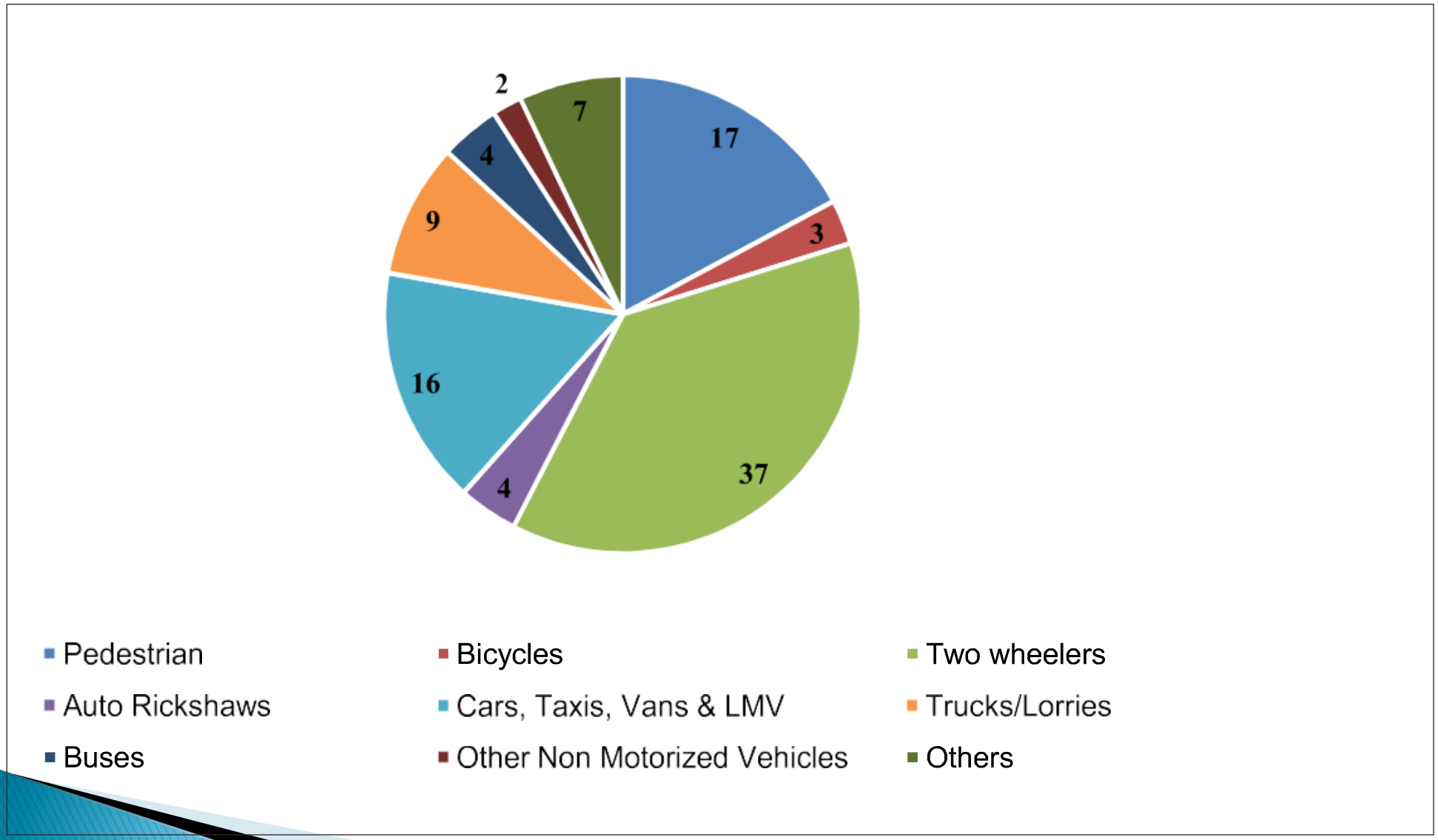
WHAT ARE VRUs?

- Pedestrians, cyclists, and motorized two-wheeler operators are called Vulnerable Road Users (VRUs).
- As per IRTAD, in 2012, there were 1605 and 10,386 VRU fatalities in Germany and USA respectively while the fatalities of VRUs in India alone was 86,196 in 2019 with pedestrian, bicycle and two wheeler motorized vehicles accounting for 3 %,17 % and 37% respectively.
- Most of the existing ITS safety applications are targeted towards vehicles, and hence the impact and usability of ITS applications for VRUs require more concrete research.
- Therefore, it is urgently required to assess the societal impact of selected ITS, and impart recommendations for policy and industry regarding ITS in order to improve the safety and mobility of VRUs.

Percentage of People killed in 2019 by Victim/ Victim Vehicle including 57 percent of VRU



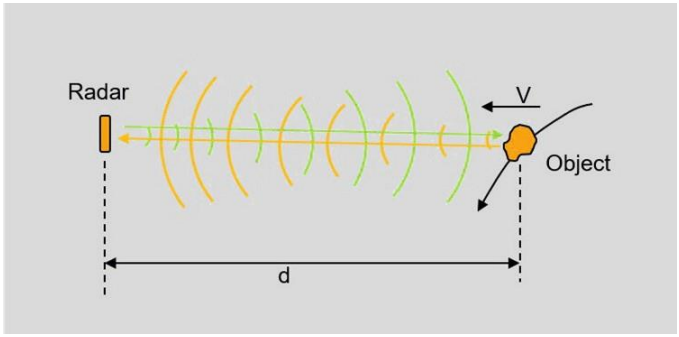
Possible ITS Areas for Applications for Safety of VRUS

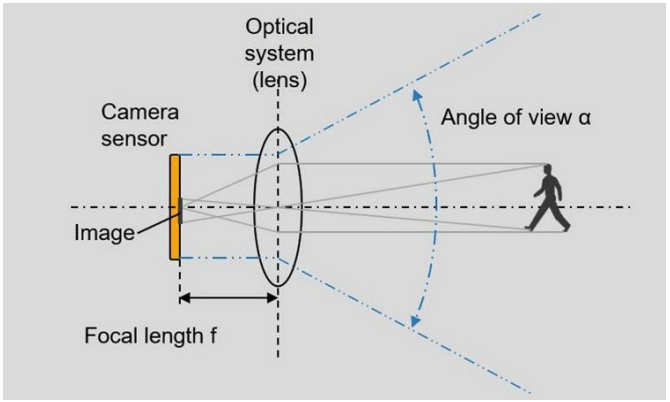
1. Blind Spot Detection
2. Intelligent Pedestrian Traffic Signal
3. Intelligent Speed Adaptation
4. Red Light and Speed Violation Detection System
5. Intersection Safety
6. Pedestrian Detection System + Emergency Braking
7. Navigation System for NMT
8. PTW Oncoming Vehicle Information System
9. Night Vision & Warning
10. Bicycle Car Communication
11. Crossing Adapting Lighting
12. VRU Beacon System
13. Forward Obstacle Detection System
14. Green Wave for Bicycles

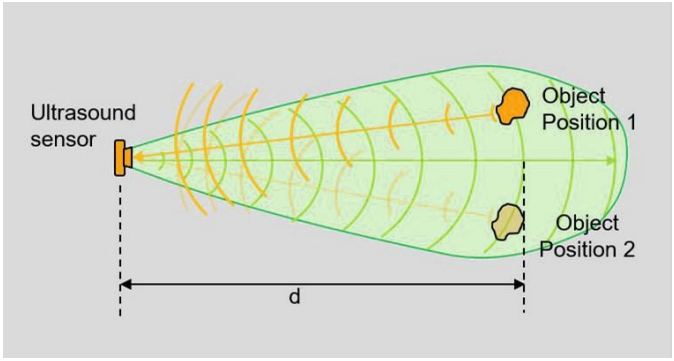
Blind Spot Monitor

Left turns by trucks are a major risk factor in traffic. Cyclists and pedestrians in the blind spot often go unnoticed, and the consequences can be fatal. The **blind spot monitor-**vehicle-based sensor is located to the driver's side and rear. Warnings can be visual, audible, vibrating.

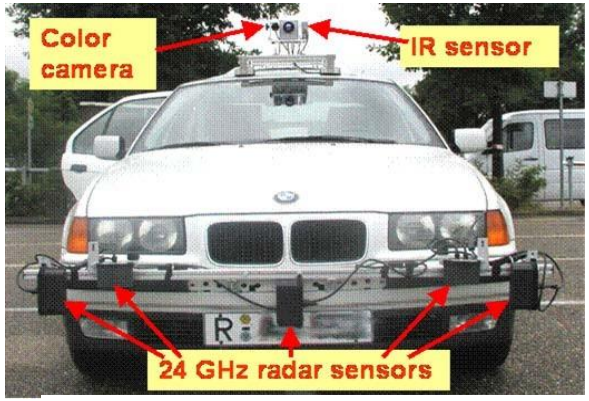
ENVIRONMENTAL CONDITIONS	Radar	Camera	Ultrasound
Day/night	✓✓	neutral	✓✓
Shadows cast by sun	✓✓	✗	✓✓
Rain	✓✓	neutral	neutral
Fog	✓✓	✗✗	neutral
Snowfall	✓	✗	✗
Dirt	✓	✗	✗
TECHNICAL CRITERIA			
Range	✓✓	✓✓	✗
Resolution	✓	✓✓	✗
Measurement of velocity	✓✓	✗	✗✗
Measurement of distance	✓	neutral	✗
Detection of objects	✓	✓✓	✓✓
Classification of objects	✓✓	✓✓	✗✗

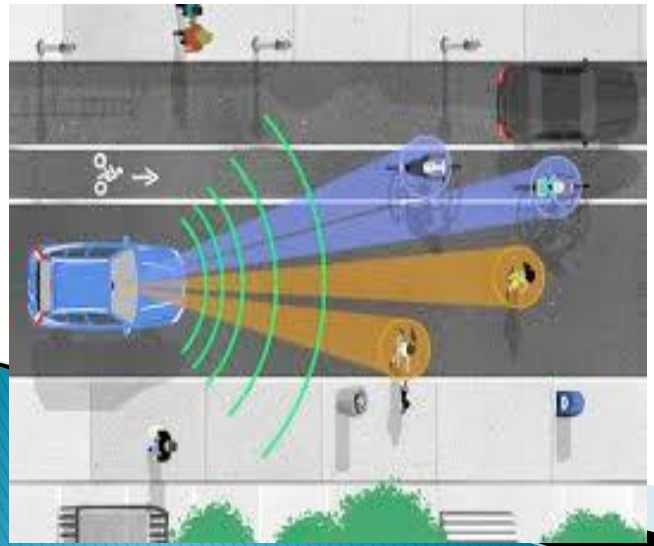






Pedestrian Detection System





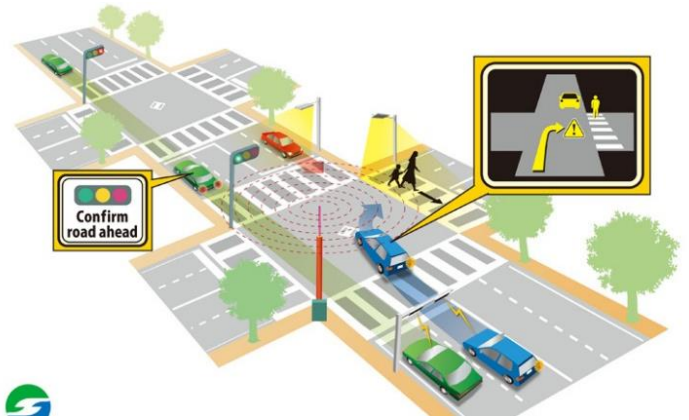
This uses a **camera combined with radar to detect vulnerable road user**s through their shape and characteristics. The way in which pedestrians move relative to the path of the vehicle is calculated to determine whether they are in danger of being struck

Alert the driver to an imminent crash and help them use the maximum braking capacity of the car and apply the brakes independently of the driver if the situation becomes critical.

It is important to note that AEB systems are designed to support the driver only in emergency situations and that the driver remains responsible for the vehicle at all times.

VRU Beacon Systems

- VRU Beacon Systems
- **SafeWay2School developed a RFID-based VRU unit for children that consists of a standalone radio unit able to communicate with intelligent bus stops, which warn drivers with flashing lights about the vicinity of VRUs.**



RADIO BACON at Intersection & Bus Stop

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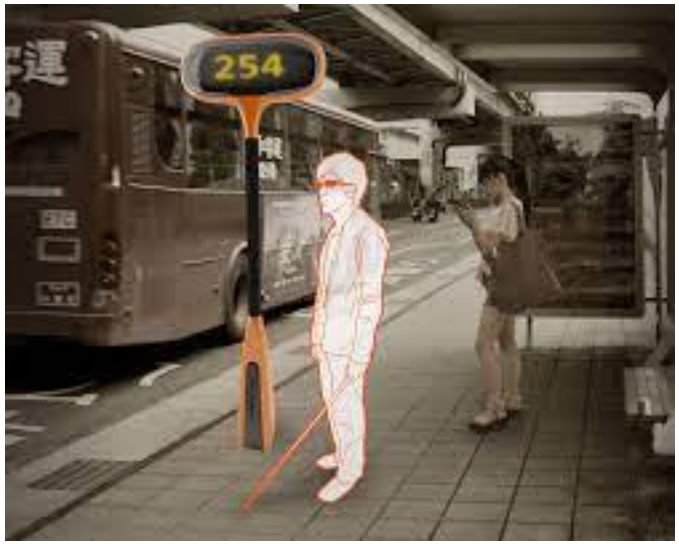
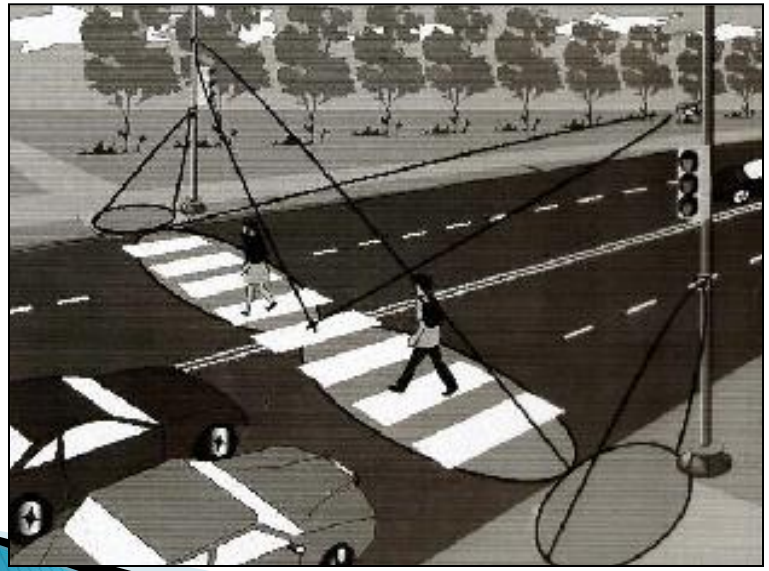
The use of tags for kids through infrastructure, such as bus stops, combined with warnings for both the bus driver, to inhibit the start at boarding and alighting, and for other vehicle drivers to warn of children presence.



Intelligent Pedestrian Signal : Traffic-Emerging Technologies: Smart pedestrian crossing- in Spain



Badajoz, Spain now has its first smart pedestrian crossing.
The traffic-light turn amber signal if a pedestrian is approaching the crossing. When a vehicle is driving down the street at over 30 kilometres per hour, a red light warns pedestrians of the danger. Safety is reinforced at night with LEDs that light up to warn cars of pedestrians at the crossing.

Automated pedestrian detection devices called PUFFIN (Pedestrian User-Friendly Intelligent) crossings have been in use in the United Kingdom for several years. They use an infrared detector or pressure-sensitive mat to sense pedestrians waiting for a crosswalk signal

Crossing Adapting Lighting in London & Mobile Accessible Pedestrian Signal System

Crossing Adapting Lighting

Mettle Studio, on another crossing project called the Line of Sight – **a strip of red LEDs that light up when pedestrians are crossing the street**. The red lights warn cars anytime someone steps onto the crossing. Once pedestrians cross the street, they flash and then go out entirely.

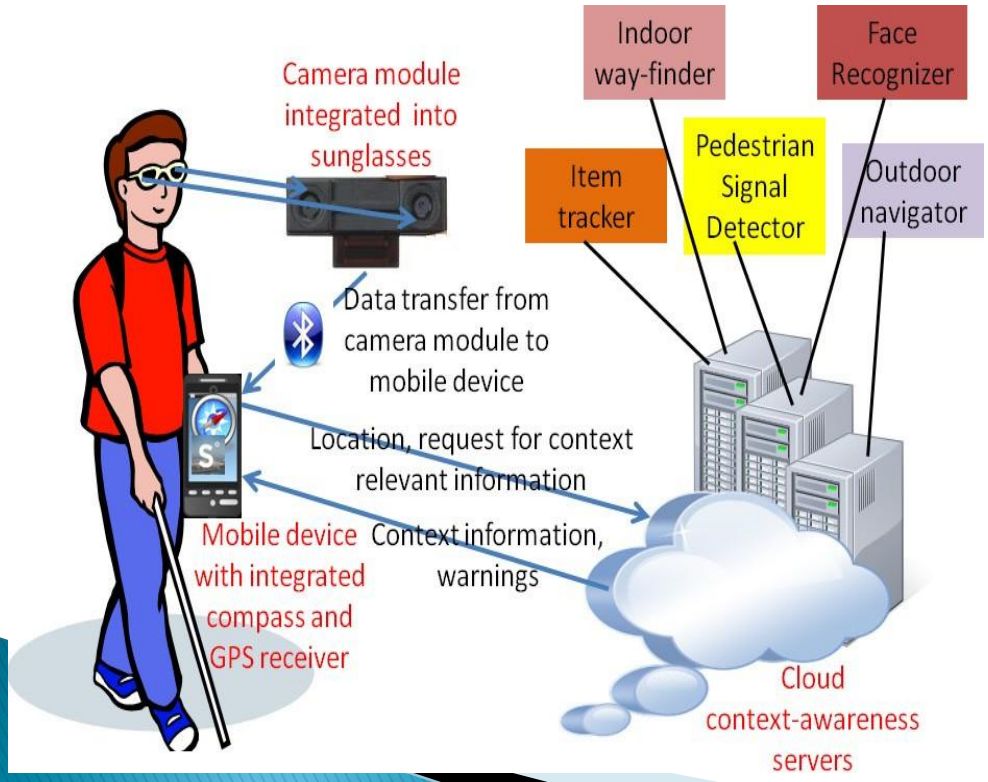
Some of the V2P applications in development include:

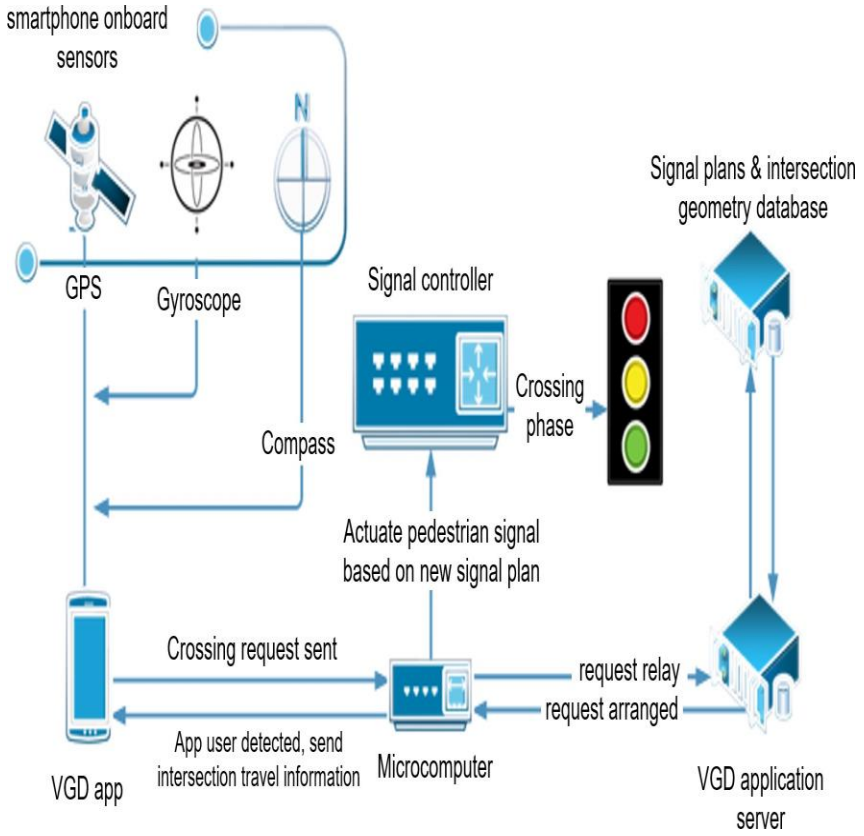
- **Mobile Accessible Pedestrian Signal System**: **An application that allows for an automated call from the smart phone of a pedestrian who is blind or has low-vision to the traffic signal.** In addition, drivers attempting to make a turn are alerted to the presence of a pedestrian at the crosswalk.

Communications to/from the traffic controller will use DSRC (5.9 GHz. 1609.x, J2735) message sets and will be available at any intersection which includes an RSU.

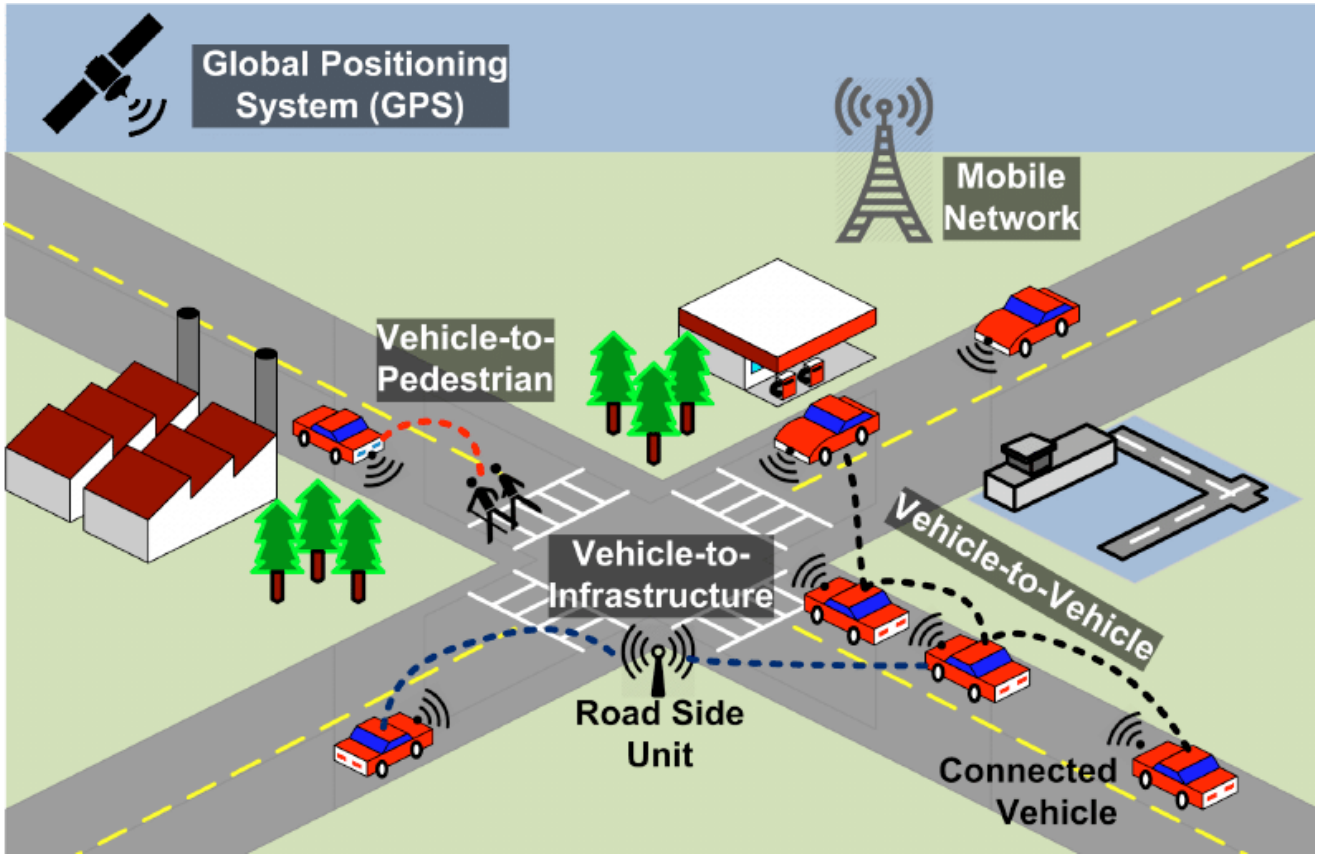
MOBILE ACCESSIBLE PEDESTRIAN SIGNAL

- **Constant GPS-based localization for a pedestrian on a roadway and crossing information based on proximity to the intersection**
- **Touchable and audible user interface for users to exchange information using wireless communication**
- **Pedestrian phase actuation without the need to press the push button**
- **Instructions, if necessary, for pedestrians to ensure alignment with the crosswalk**
- **Wireless communication with a traffic signal controller via Bluetooth**





Examples of V2P with Direct & Indirect



A V2P system that enables the exchange of safety messages through a combination of cellular infrastructure and direct Wi-Fi communication. A central information processing server processes the safety messages that it receives from vehicles and pedestrians and calculates the collision risk.

Sensors, Method and System Type for V2P

Reference	Year	Sensors	Method	System Type
[33]	2008	GPS	Collision Risk Evaluation	Pedestrian-to-vehicle communication system
[32]	2011	GPS, Accelerometer	Pedestrian Movement Recognition	Collision Avoidance
[34]	2011	Accelerometer	Prediction of Pedestrian Behavior	Patented Method for avoiding collision
[31]	2013	GPS, Accelerometer, Gyroscope, Compass ..	Dead Reckoning Algorithm	GPS Positioning in VRU Protection Systems
[14]	2014	GPS	V2P Wireless Communication	Cellular technologies user for for V2P applications
[19]	2014	Accelerometer, Gyroscope, Compass	Sensors Fusion	Driver Detection System
[20]	2014	Wi-Fi, GPS, Gyroscope, Accelerometer, Magnetometer	Pedestrian/Vehicle Path Prediction	A DSRC based vehicle-pedestrian safety system
[21]	2014	Accelerometer, GPS	Smartphone Sensors Fusion	Pedestrians risk classification
[30]	2015	GPS, Accelerometer, Gyroscope, Compass, Gravity, Magnetometer	Smartphone Sensors Fusion	Sensing unsafe pedestrian movements
[1]	2016	GPS, Accelerometer, Gyroscope, Compass, Gravity, Magnetometer	Sensors Fusion	Smartphone Based Transport Safety System
[22]	2016	GPS, Accelerometer, Gyroscope	Sensors Fusion	Pedestrian Safety with mobile crowd sensing
[23]	2016	GPS, Magnetometer	Collision Prediction Algorithm	Collision Prediction Algorithm for P2V and V2P
[24]	2016	GPS, Accelerometer, Gyroscope, Magnetometer	Sensors Fusion	Traffic safety framework by sensing driving behavior
[25]	2016	GPS	Vehicle GPS Data Fusion	V2P to enhance VRUs' safety
[26]	2016	GPS, Acccelerometer, Magnetometer, Gyroscope	Sensors Fusion, Collision Prediction	VRU protection system
[27]	2017	GPS, Acccelerometer	Sensors Fusion,VRU Context/Activity	Smartphone collision avoidance system
[28]	2017	GPS, Accelerometer, Gyroscope, Magnetometer	VRUs Future Position Prediction	V2X pedestrian collision avoidance system
[29]	2017	GPS, WiFi	VRUs position broadcast via WiFi	Wi-Fi Pedestrian Collision Avoidance System



The VRUITS project: ITS applications for VRUs

Project Background

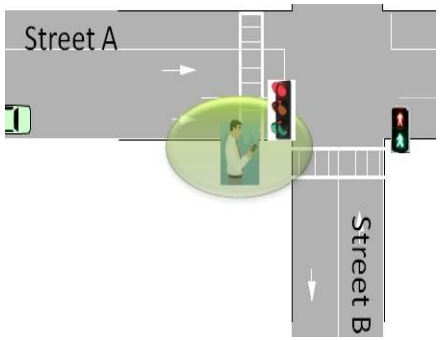
Duration: 1.4.2013-31.3.2016

- ITS systems have resulted in the the reduction of fatalities in the EU.
- ITS development has primarily focussed towards vehicle-centric
- VRU fatalities have not decreased in the same level as other road users:
  - Fatalities among car occupants were reduced by 50% between 2000 and 2012, whereas decreases were only 34% for pedestrians, 31% for cyclists and 17% for motorcyclists (IRTAD, 2014).

The VRU has to be an active, integrated element in the ITS, addressing safety, mobility and travel comfort of VRUs

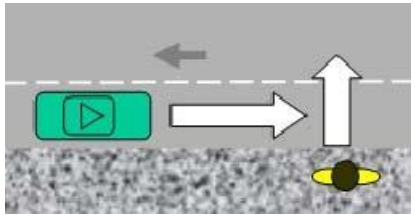
VRUITS Main Objectives

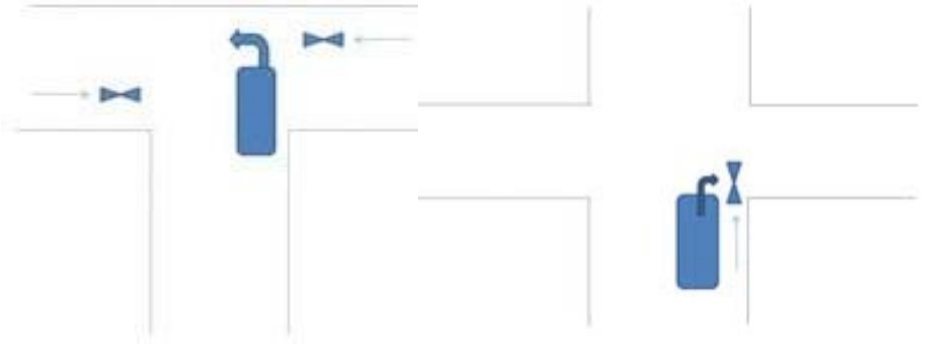
1. To assess societal impacts of selected ITS, and provide recommendations for policy and industry regarding ITS in order to improve the safety and mobility of VRUs;
2. To provide evidence-based recommended practices on how VRU can be integrated in Intelligent Transport Systems and on how HMI designs can be adapted to meet the needs of VRUs, and test these recommendations in field trials



Most critical scenarios

- **Data sources:** CARE, national databases (UK,SE,SP,FI), in-depth studies (SafetyNet, Pendant, MAIDS)

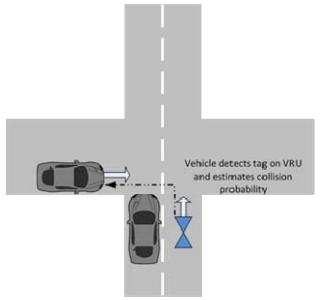




Pedestrians	Cyclists & PTWs	
Pedestrian crossing the road at mid-block	At junctions:	
	Vehicle pulling out into the path of oncoming VRU	Vehicle turning into VRU's path

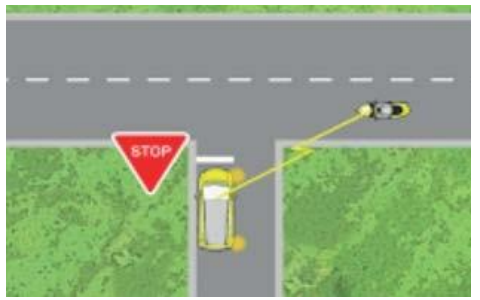
Co-operative systems assessed by VRUITS (1/2)

VRU beacon system: VRU has tag that broadcast data. The vehicle driver is warned about potential collisions



PTW oncoming Vehicle Information System

PTW riders and cars exchange messages and are warned of potential collisions

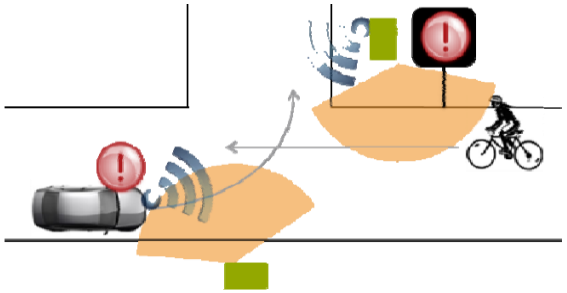


Bicycle to vehicle communications: Cyclists and cars exchange messages and are warned of potential collisions

Co-operative systems assessed by VRUITS (2/2)

Green wave for cyclists: System provides speed advice to cyclists

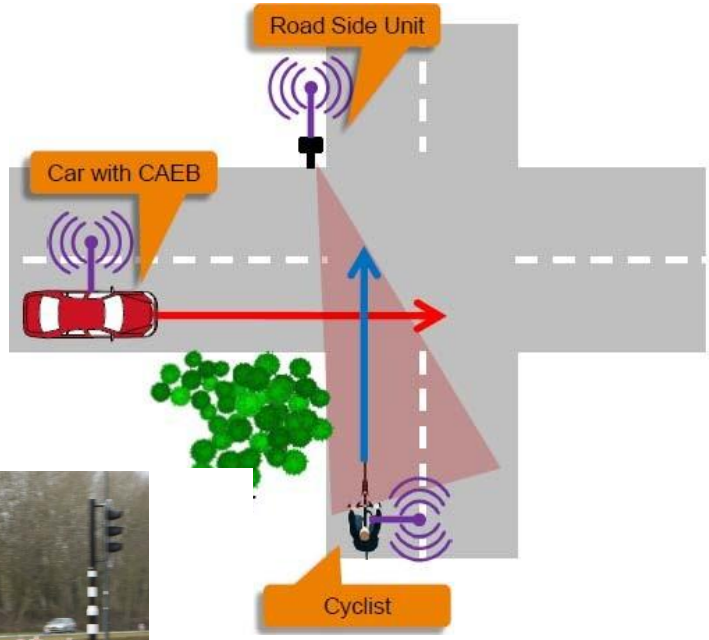
Intersection safety: Road side unit detects VRUs and warns road users



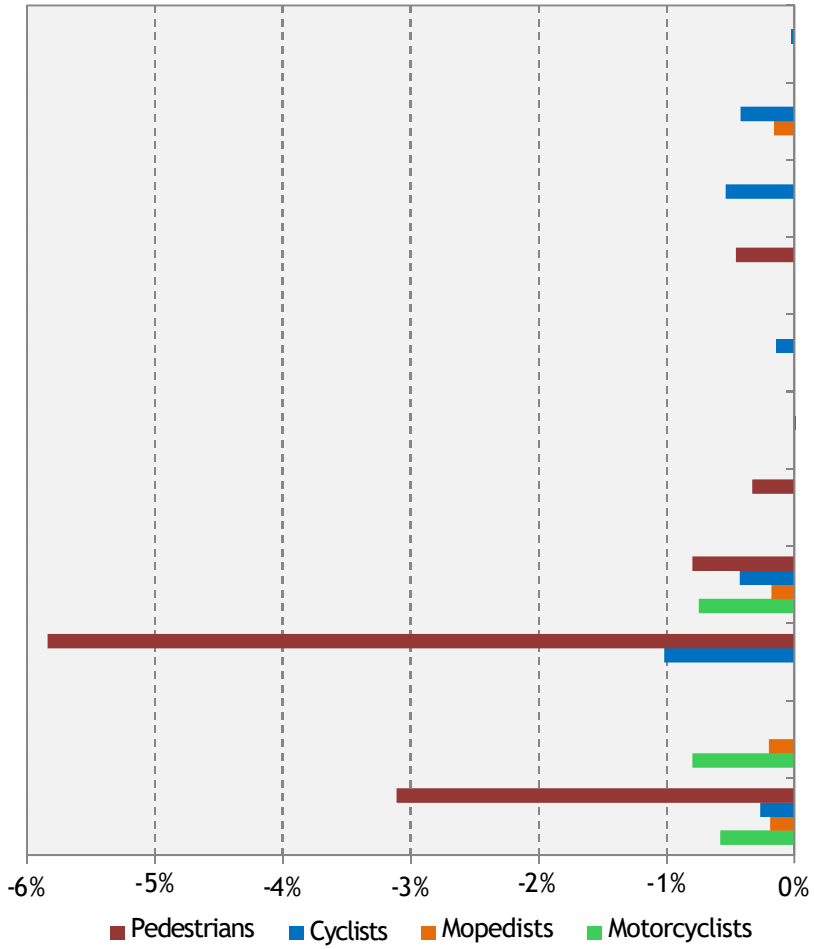
VRUITS Trials: Helmond

Intersection Safety with Cooperative AEB

VRU detects cyclists and PTWs and send data to car; car assesses risk; warns both driver and sends message to cyclist, car brakes automatically. Cyclist is warned (haptic & visual)



Safety Results by VRU group,
% reduction of all road fatalities, EU-28 (100% penetration)



Blind Spot Detection (BSV)I

cycle-to-Vehicle Crossing(C2V)

Adaptive Lighting Green Wave for

Cyclists (CAL) Info. Bike Vacancy(IVB)

Intelligent Pedestrian Traffic (IPT)
Signal

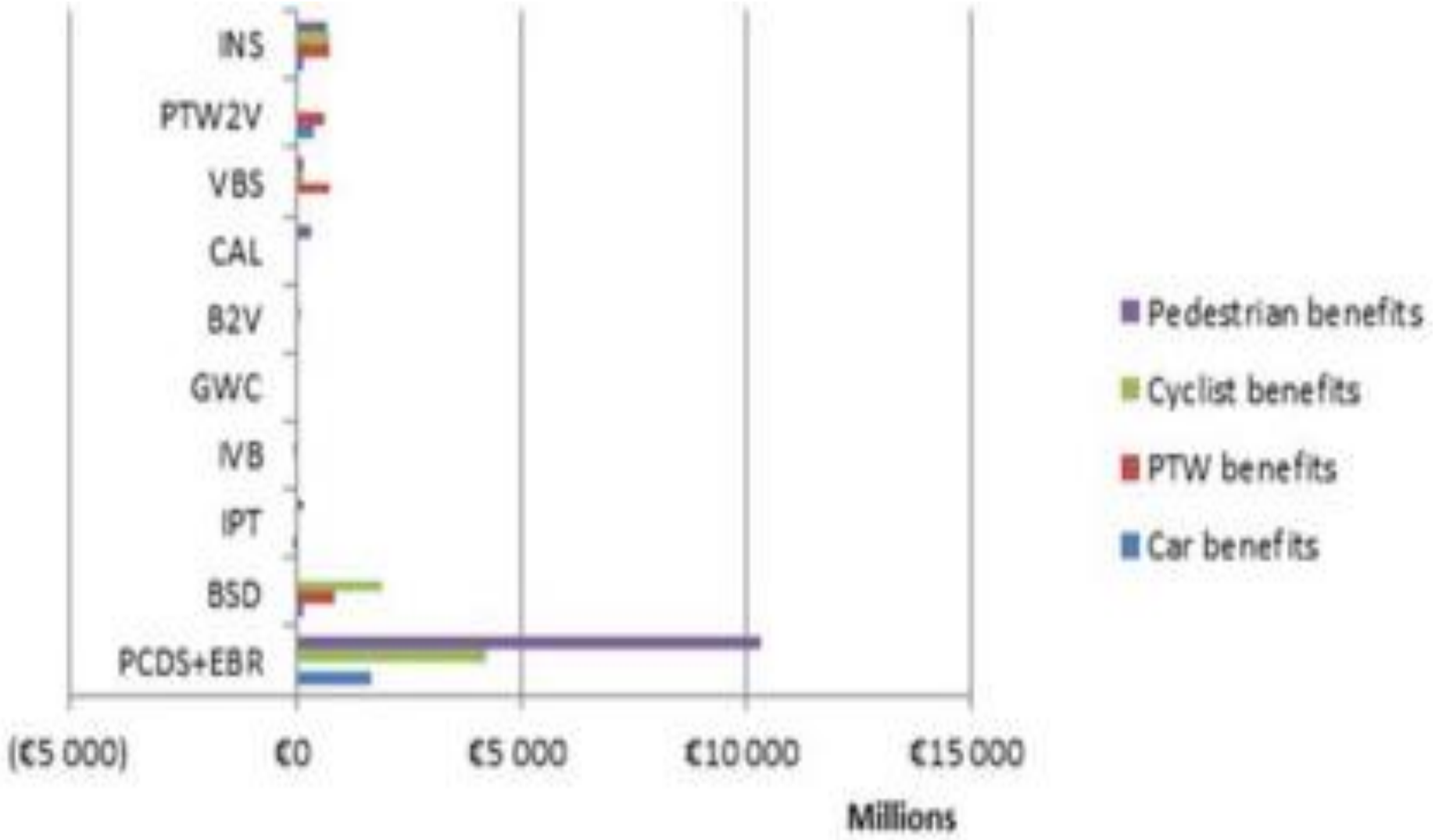
Intersection Safety (INS)

Pedestrian Detection+
Emergency Braking (PCDS+ EBR)

PTW-to-Vehicle

VRU Beacon System (VBS)

ITS impact costs of implementation and safety benefits for the different road user groups (in M€).



CBA Results medium scenario 2030

	Cost Efficiency		
Effectiveness	Benefit – Cost (BC) ratio		
NPV of Benefits	<1	(1-3)	>3
< 500 M€	IVB (information on Bike Vacacy), BSD(Blind Spot Detection)*	GWC (Green Wave Cycles)	B2V (Bike to Veh), CAL(Adap light Green Wave)
> 500 M€	PCDS (ped Dec Sys)+EBR, BSD	VBS(VRU Beacon System , IPT(Intel Ped Sig), PCDS+EBR *	INS (Int Sef), PTW2V

A CLOSER LOOK

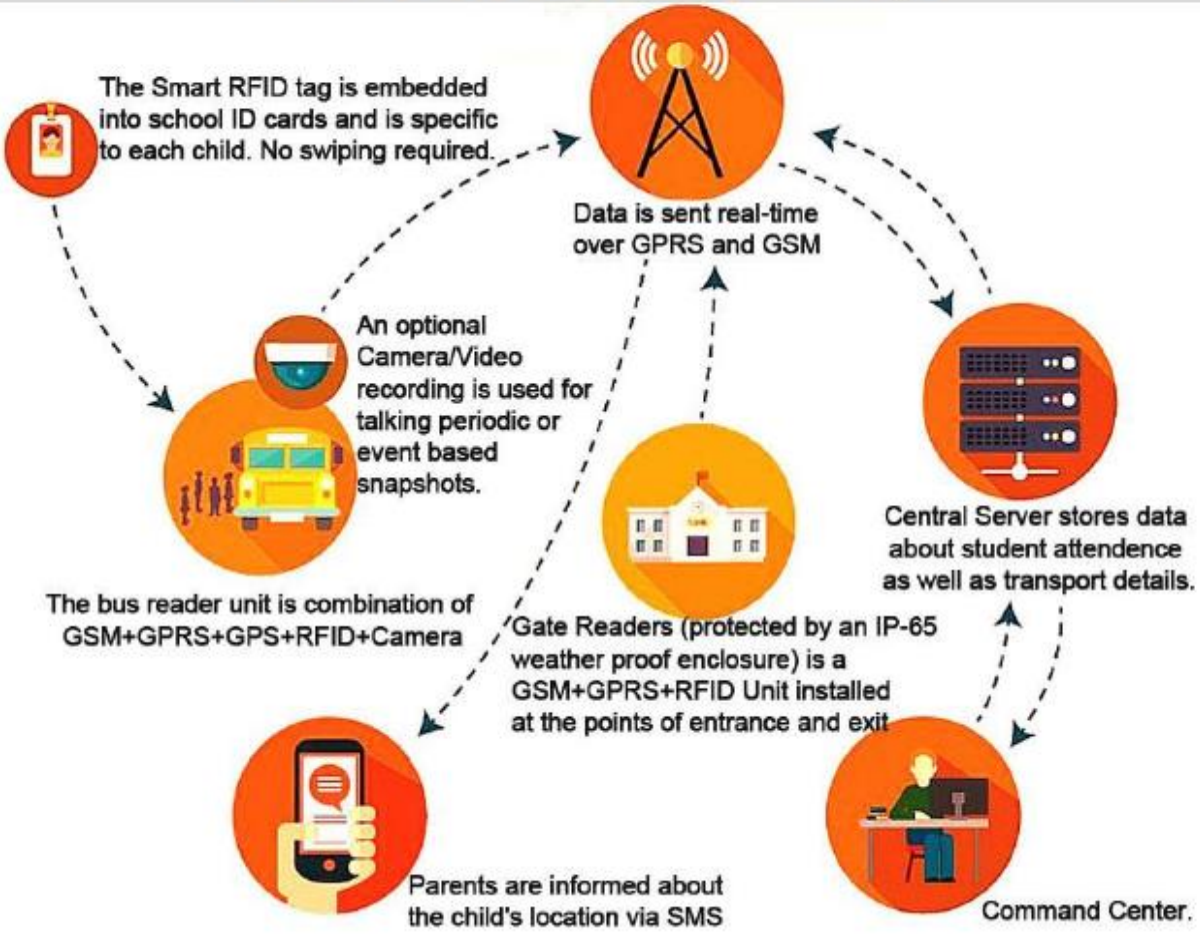
Summary of V2P Detection and Notification Technology

Technology		Vehicle	Pedestrian	Infrastructure
Communication Method	DSRC	DSRC Radio	DSRC-Capable Phone	
	GPS via Cell	Smart Phone	Smart Phone	X
	Wi-Fi Direct	Wi-Fi Direct Equipped	Wi-Fi Direct Capable Phone	X
	Infrastructure Sensors	DSRC Radio		X
Notification Method		Display	Phone Screen + Audio	
		Vehicle Speakers	Wearable Technology	

BIS Study for standardizations on School Bus Safety for Children

KRISE

How It works centrally?



Conclusions

- **VRUs are most neglected road users involved more than 50 percent of fatalities in most of the countries in world including India.**
- **It is increasingly observed that the use of Intelligent Transport Of Total of 14 areas suggested, it is extremely necessary to identify, recommend and implement the following :**
- **i) Automatic Pedestrian Detection System, ii) VRU Beacon Systems, iii) Powered Two Wheelers oncoming Vehicle information, iv) Bicycle-to-vehicle communication, v) Blind Spot Monitoring**
- **The study reveals substantial benefits being accrued to VRU as well as other modes of transport.**
- **Standardisation of communication technologies and interfaces is required taking into account VRU devices restrictions, as e.g. power consumption, limited range, sensor accuracy**
- **Research on improving location accuracy of VRU devices (<0.5 m) is of urgent importance**

KNOW MORE AT:
https://www.youtube.com/watch?v=RHlAfK6g2WA

THANK YOU