Developments in designing safer vehicles for urban transport: an issue of sustainable development

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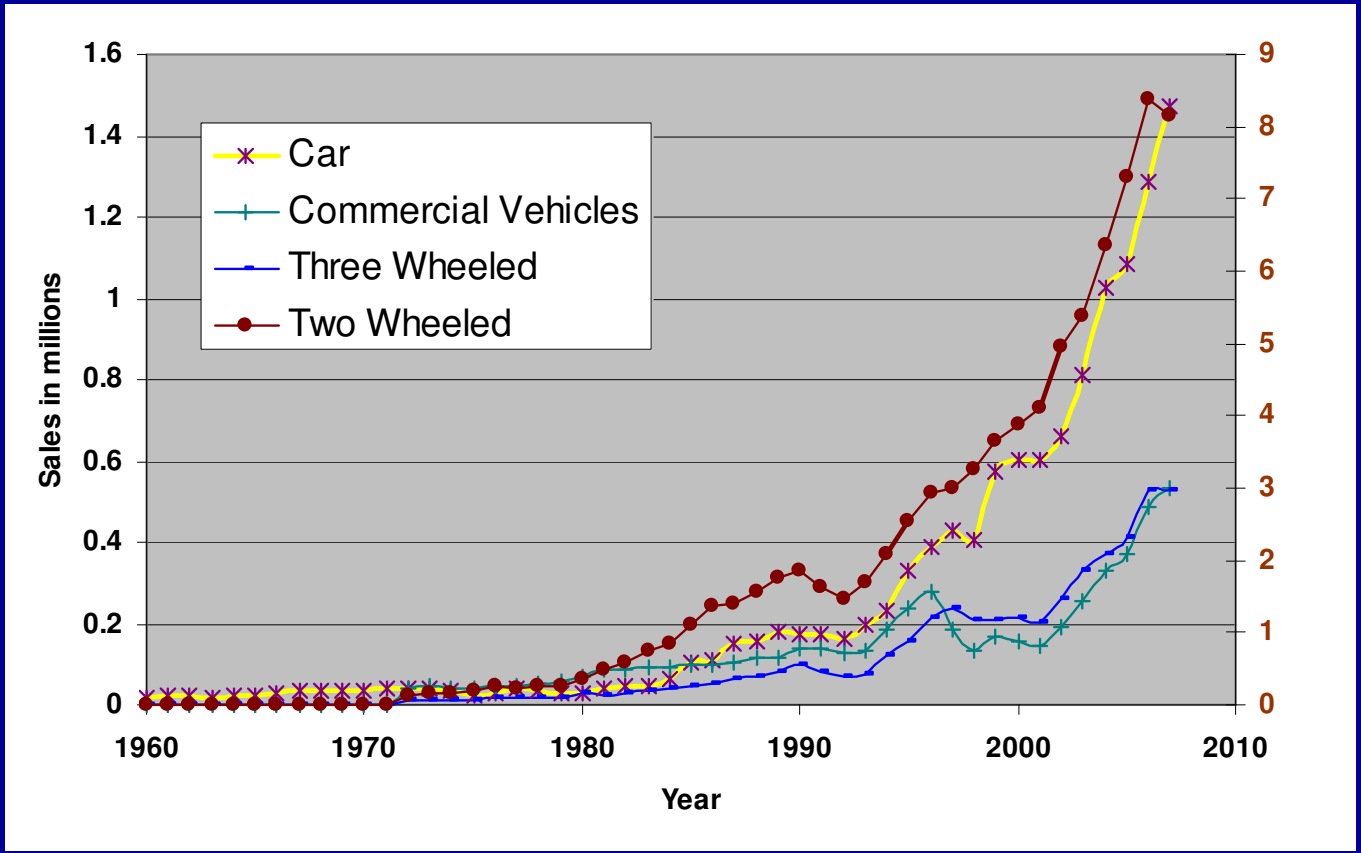
An India-centric analysis

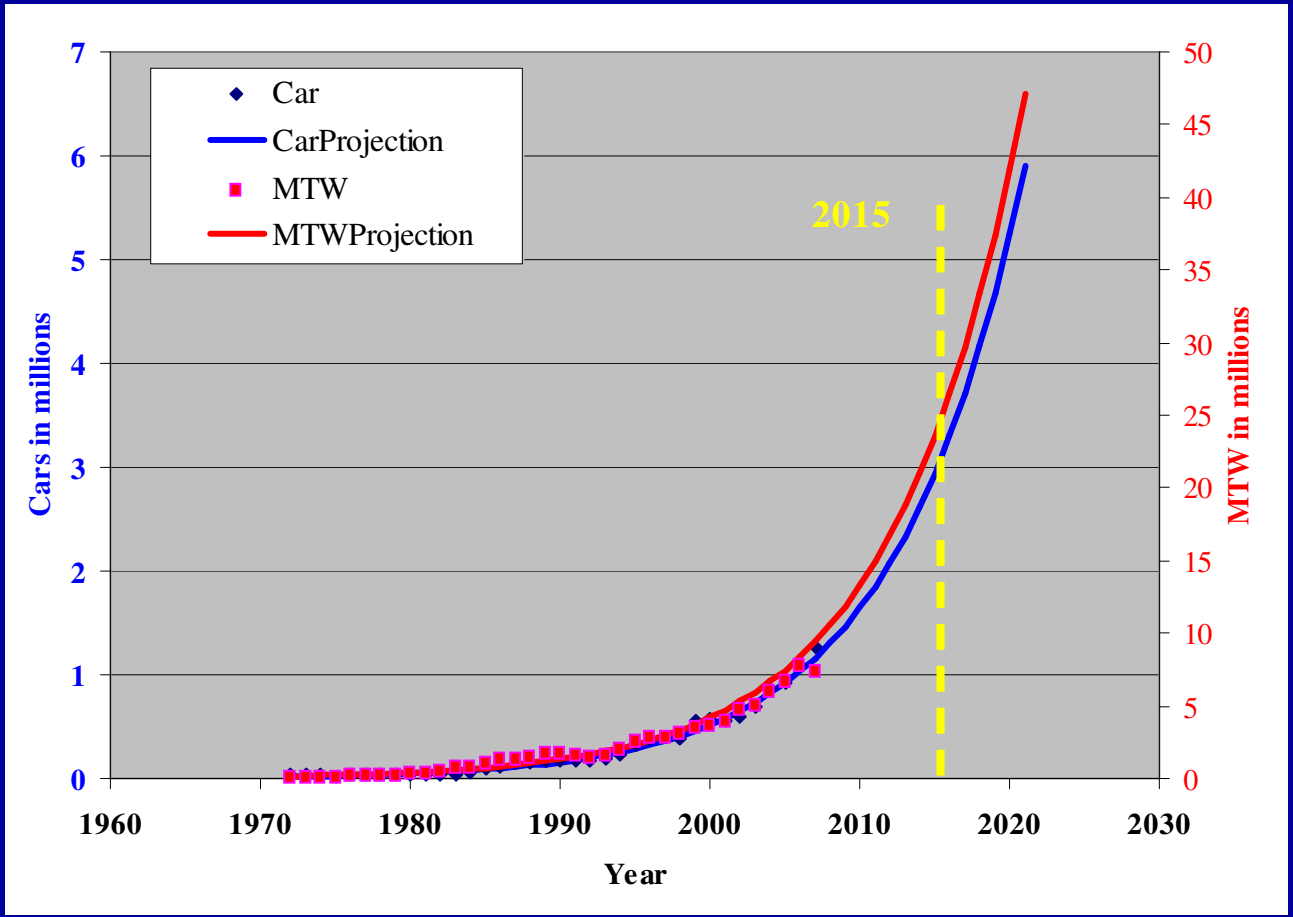
- Mass wisdom demonstrates awareness of what is safe and comfortable transit.
- What then is the demand for vehicles in 2015?
- Everything out of the tailpipe is a concern.
- Demands crash safety in small vehicles
- Technology: Finite Element Human Body Models

Vehicles registered in India



- India population is about 1.2 billion
- We estimate about 70% of registered vehicles to be on the road

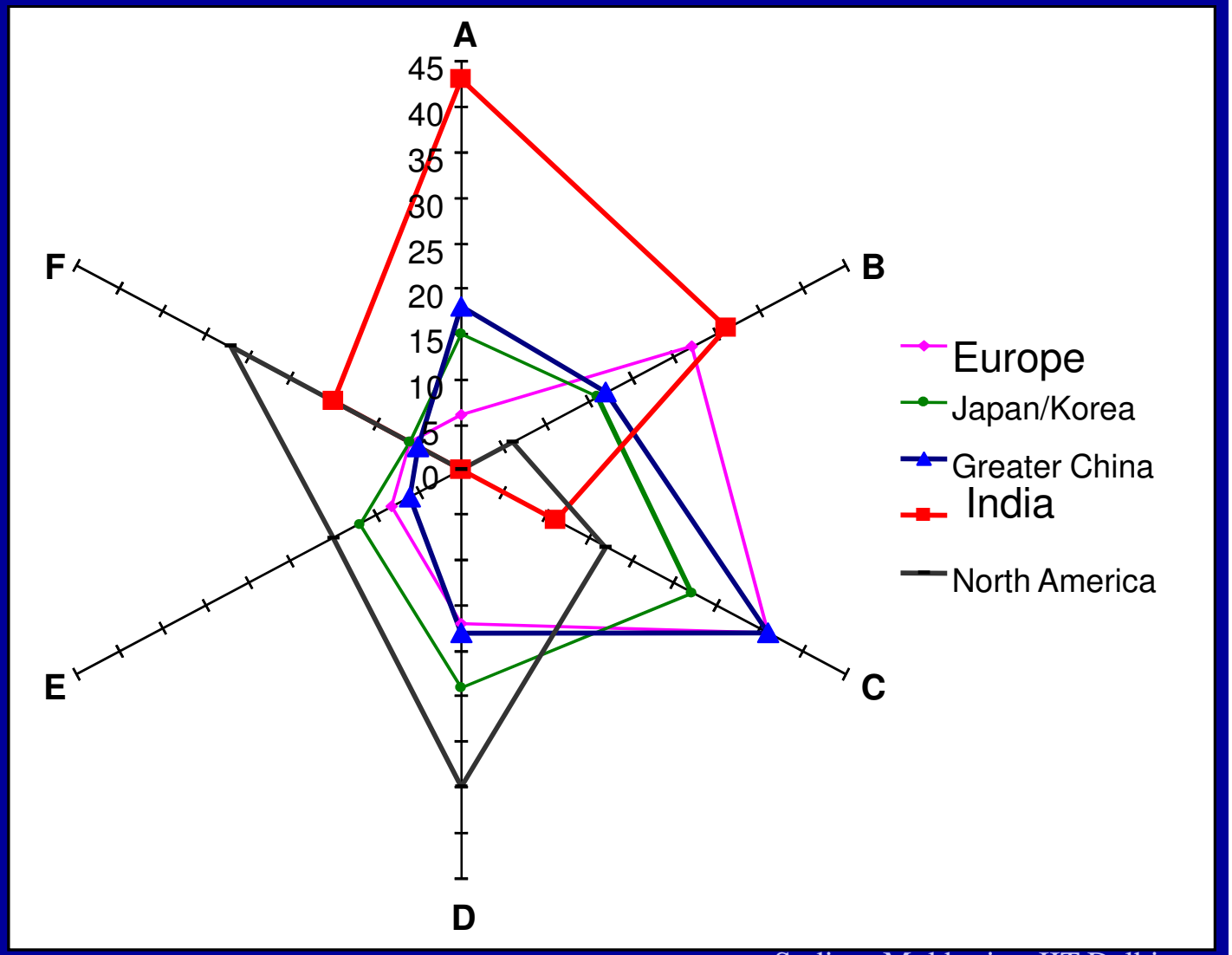
Projections



- Look at year 2015
- Projected car sales of 2.9 million and MTW sales of 23.6 million

Estimated car segment share in 2013 (CSM)

- A & B: supermini
- C: small family car
- D: Large family car
- E: Executive car
- F: Luxury



How many small cars

- We predict an “A” segment sales of 1.3 million cars per year assuming business as usual and no major hiccups in development trends.
- The entry of even smaller cars may comprise a portion of the segment A sales (around 1 million or less in 2015)
- Some proportion of the segment occupied by TWs
- International data show that countries that have a history of high motorcycle ownership, also have relatively lower car ownership rates.
- The above numbers are unlikely to change dramatically in the next five years.

WHO World Report on Road Traffic Injury (Peden et al., 2004)

1990	2020
1 Lower respiratory infections	1 Ischaemic heart disease
2 Diarrhoeal diseases	2 Unipolar major depression
3 Perinatal conditions	3 Road traffic injuries
4 Unipolar major depression	4 Cerebrovascular disease
5 Ischaemic heart disease	5 Chronic obstructive pulmonary disease
6 Cerebrovascular disease	6 Lower respiratory infections
7 Tuberculosis	7 Tuberculosis
8 Measles	8 War
9 Road traffic injuries	9 Diarrhoeal diseases
10 Congenital abnormalities	10 HIV

- The release of the IPCC report on climate change has changed the ground rules and transportation planning

Growth countries like India

- The poorer sections of the population may increase their consumption to reach "comfortable" living norms.
- The richest in India (read car owners) will have to reduce their CO_2 emissions like in Europe.

(Georgakellos, 2008)

	Internal combustion engine vehicles	Hybrid electric vehicles	Fuel-cell vehicles methanol	Fuel-cell vehicles hydrogen	Battery-powered electric vehicles
Energy use (kW h/10 km)	4	3	3.2	2.6	1.7
NOx (g/km)	0.06	0.04	0.04	0.03	0.04
VOC (g/km)	0.043	0.010	0.010	0.008	0.001
PM (g/km)	1.20	0.90	0.96	0.78	2.50
CO_2 (g/km)	12.0	9.0	0.6	0.78	1.5

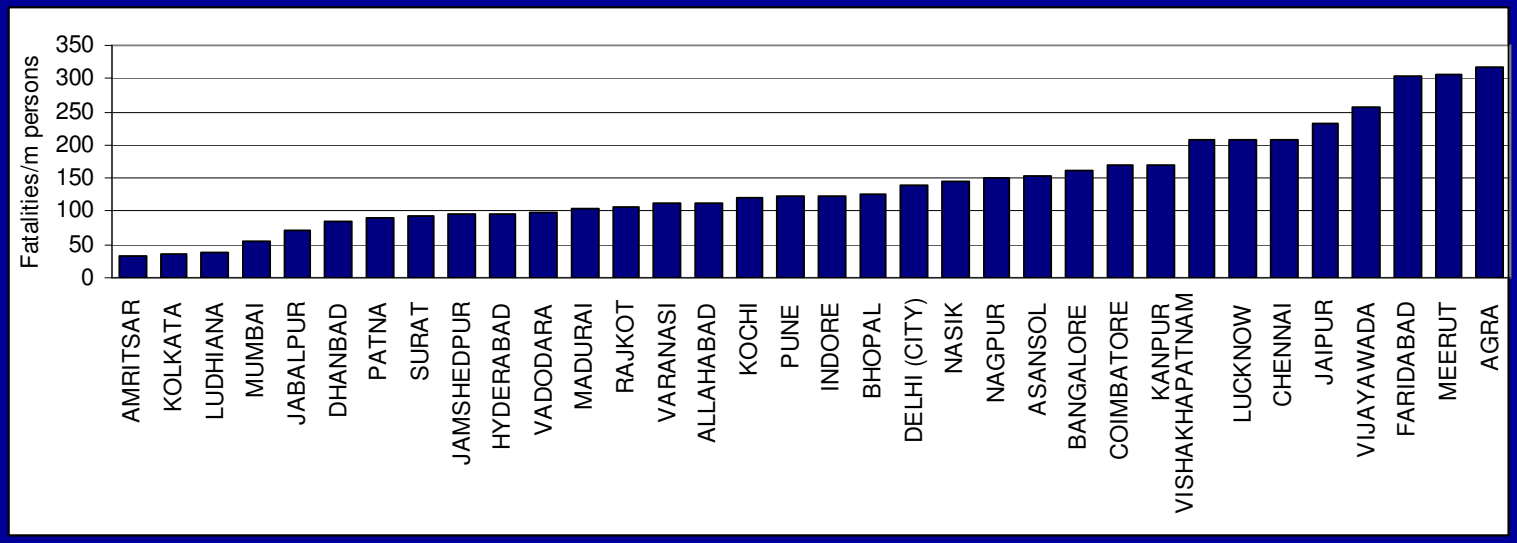
- CO_2 emissions from internal combustion engines are the highest.
- None of the other technologies are likely to be economically feasible by 2015
- Minimise the size of the engine to enable benefits from lower CO_2 and other pollutant emissions

Estimate for CO_2 emissions for a fleet of 100 cars in India

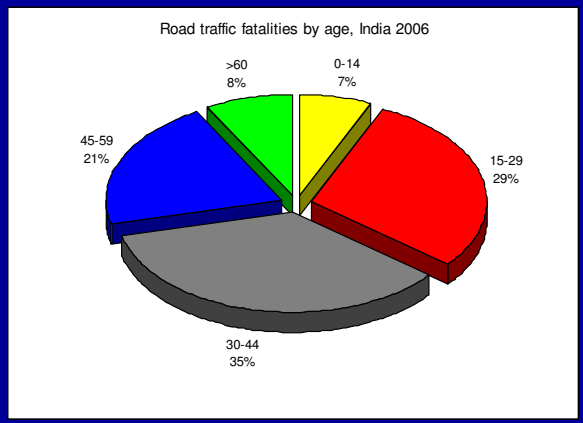
Car segment	Proportion in 2015, %	Average, engine capacity	Estimated CO_2 /km	Emission/km for car share
A	43	1000	125	5,375
B	31	1500	170	5,270
C	11	2000	200	2,200
F	15	3500	260	3,900
Total CO_2 per km for fleet of 100 cars				16,745

- Fewer and shorter trips to propose a vehicle with smaller size and hence peak speeds
- ~600 cc engine giving 30 km/l fuel consumption and 80 g/km CO_2 emissions.
- Tax based on CO_2 emissions, parking charges and road use charge proportionate to vehicle size
- Car share programmes will be needed.
- Development of the technology

Fatality rates in Indian cities , 2006



- No regional dependence
- Majority of those killed are in the working age group
- The urban vehicle must not exacerbate this trend

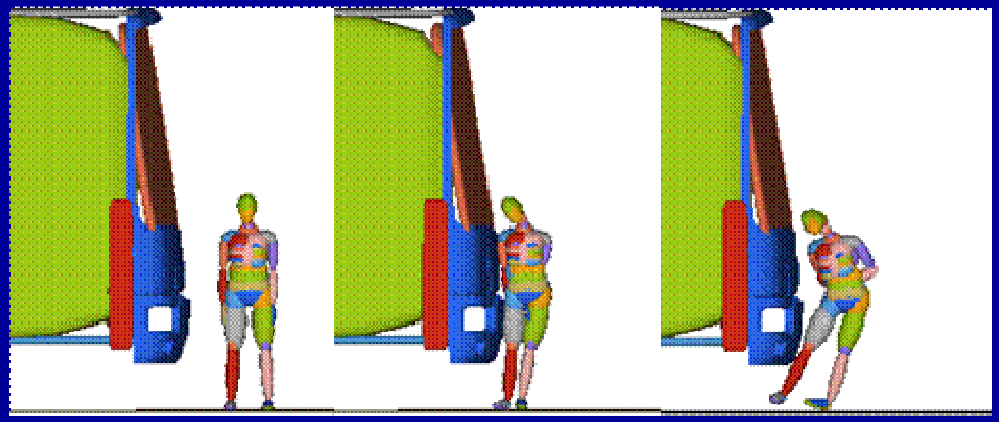


Car for the domain

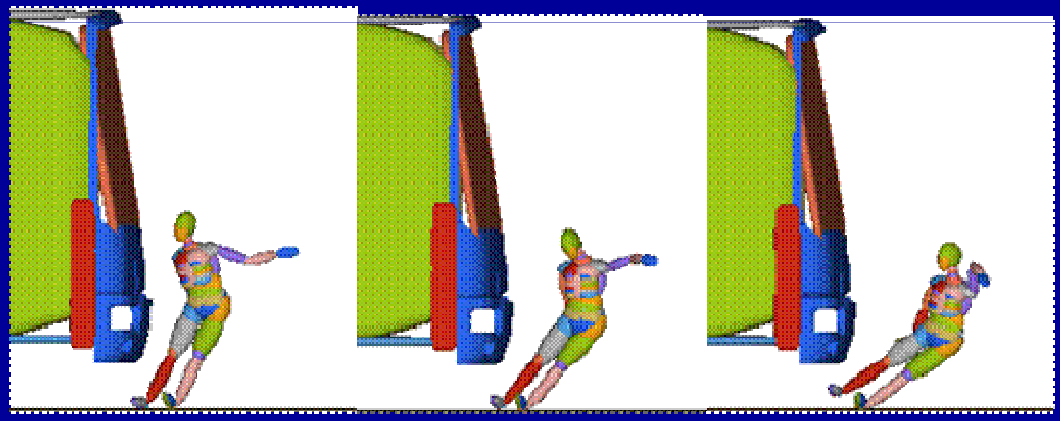
- No mini car does well in pedestrian impact protection at present
- Smallest mainstream European car has a top speed of around 130 km/h.
- Fuel efficiency and emissions are compromised because of unnecessary mass and engine performance
- Their size adds to congestion.

Pedestrian Safety

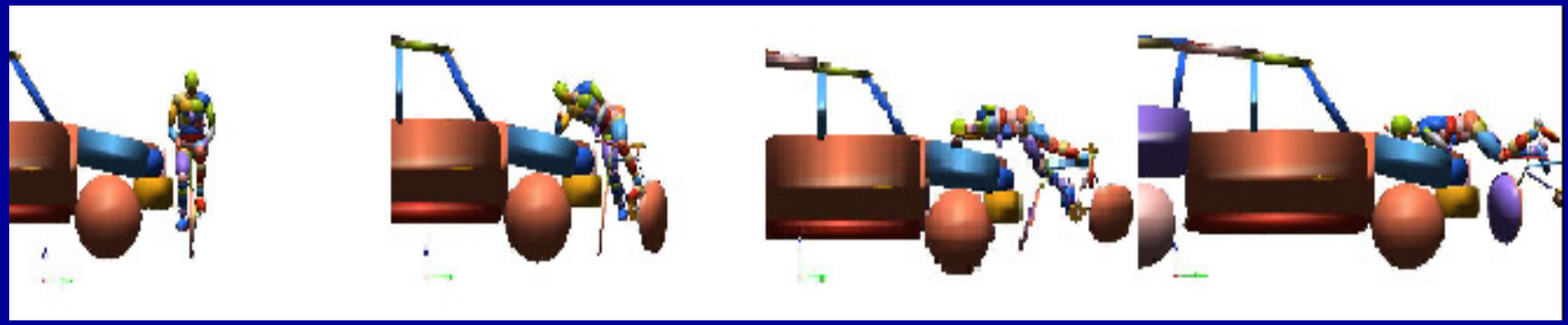
- Circumstances of pedestrian/car collisions in western environmentshas been translated into the EU directive governing exterior design and the pedestrian requirements of EuroNCAP.
- Difficult to protect the urban pedestrian effectively with current model of a single car and standard for every usage.
  - At speeds below 40 km/h the incidence of serious chest and hip injuries is much less (Ashton and Mackay, 1979; Otte, 2001).
- We would suggest that the urban car should be evaluated only against head and lower limb measures at 40 km/h.



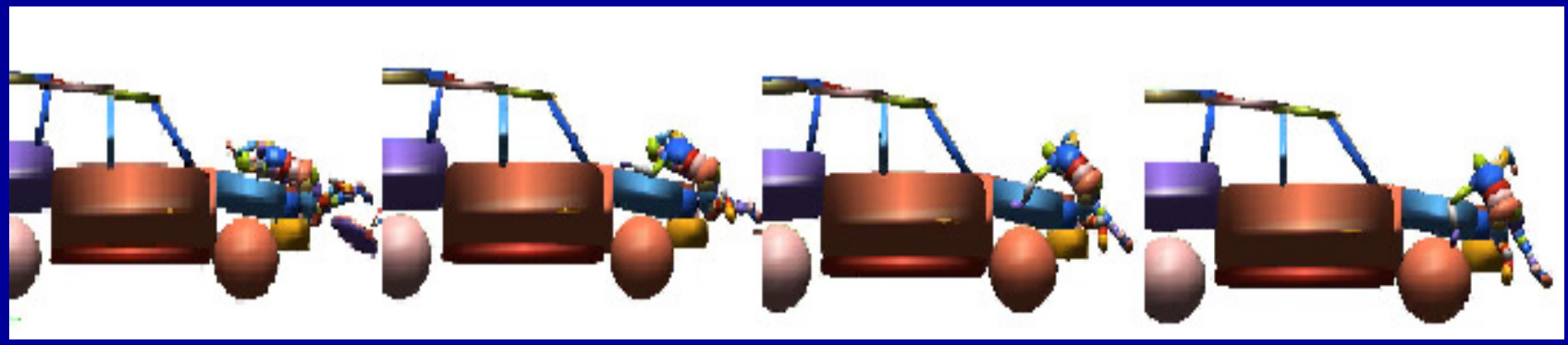
Time 50ms Time 100ms Time 150ms



Time 200ms Time 250ms Time 300ms



T= 0ms T=100ms T=200ms T=300ms



T= 400ms T=500ms T=600ms T=700ms

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Ideas

- Pedestrian Crush Zone
  - Forward components provide for protection of occupants in 50 km/h barrier crash by providing a ride-down distance of around 50 cm.
  - Just 5 cm of appropriate deceleration distance for the pedestrian at the 20 – 40 km/h level will greatly reduce the risk of those injuries occurring.
- Bumper
  - Clinical studies have shown that if the leg is not struck at the knee, preferably below, the outcomes are more favourable (Cesari, 2007).
  - Standard height of bumpers is 560 mm above the ground
  - Average knee height of an adult. The upper edge of the bumper should be not be higher than 350 mm.
  - Also has benefits for children in that it reduces the incidence of being run over by the vehicle, a particularly hostile and often fatal type of accident.
- Lights
  - Consider positioning them at pedestrian/cyclist head height instead of sitting driver head height

Rollover

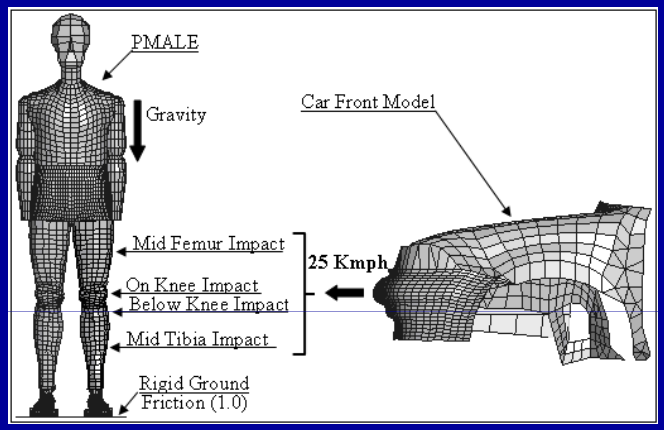
- Rollover incidents are associated only with high speed crashes
- Relax the rollover requirements
- Focus only on frontal, lateral and rear end collisions.
- Reduce the structural integrity requirements of the upper sections of the vehicle structure to protect VRU head.
- Use softer, impact friendly materials, including plastic.

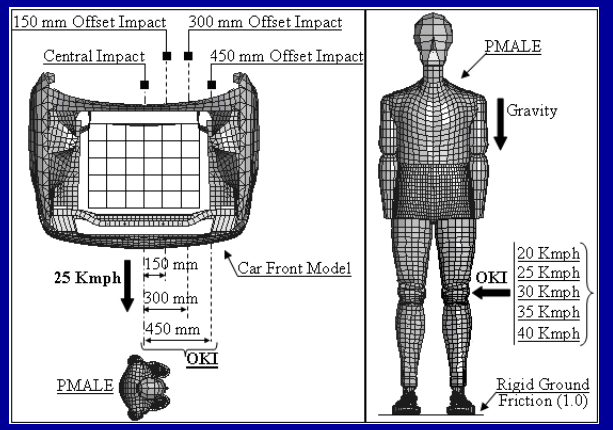
New Methods: http://www.ghbmc.com/

- GHBMC plans to build over several years a family of virtual humans, from children to elderly
- Pedestrian crashes occur in a variety of postures (like stationary, walking, running or jogging etc).
- These postures are directly controlled by muscles; therefore, they are expected to modify the crash outcomes.
- Active muscles when contracted for the locomotion or for the postural control, share the load with ligaments, and eventually unload them.

Use

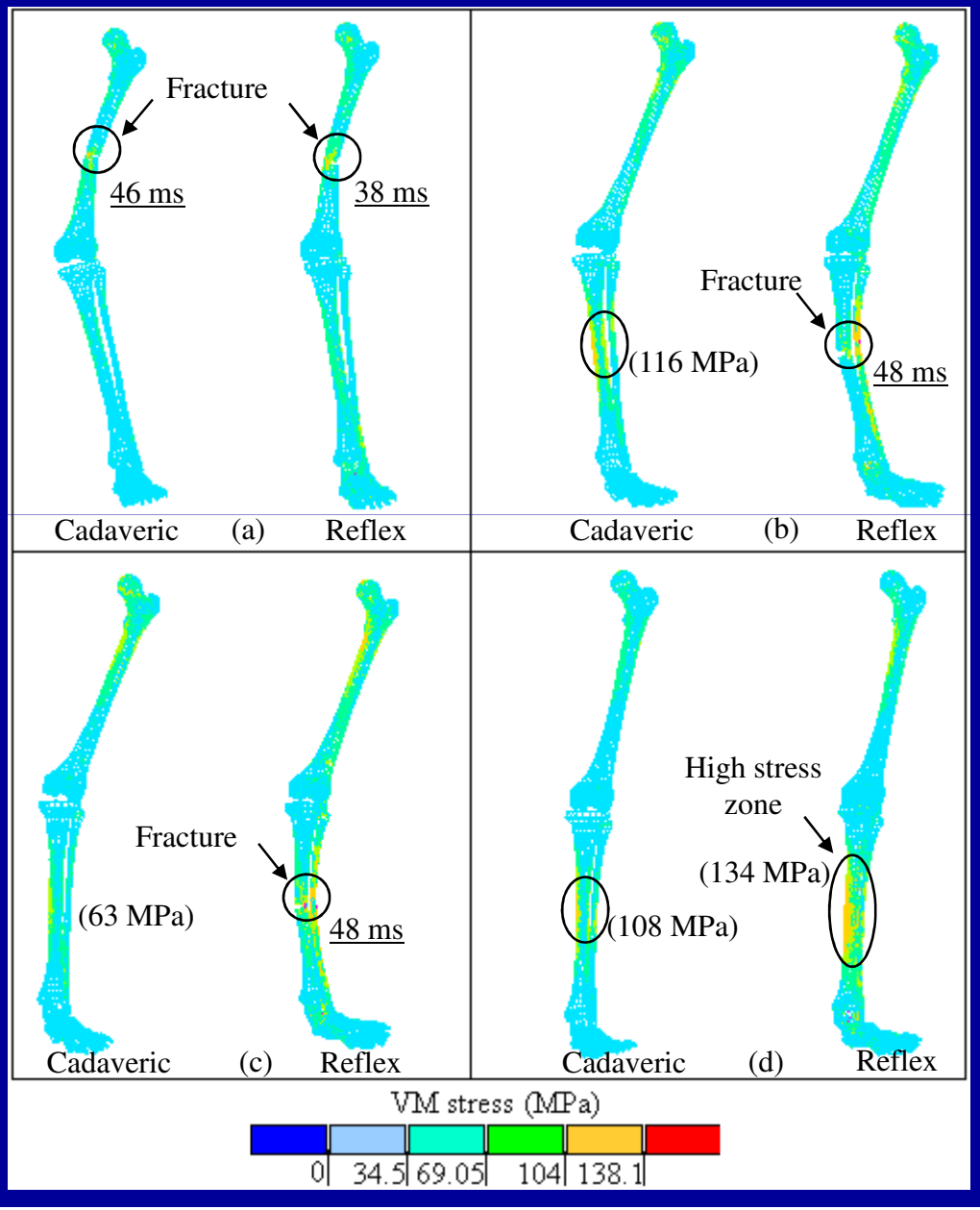
- Analyse numerous of configuration representative of crash distribution.
- Be able to change posture and muscle activation.
- Use models representative of population





Results

- Mid Femur Impact
- On Knee Impact
- Below Knee Impact
- Mid Tibia Impact



So…..

- Urban car with an engine displacement of 600cc, with peak speed around 50 km/h.
- With a city reorganised for mass public transit, this urban car would have mean trip durations of 12 mins, enabling a low mass design satisfying occupant and pedestrian safety measures.
- New materials for the car structure including plastics and microstructured compositions.
- Several emerging technology including short range radar and FE human body models would enhance active and passive safety for vulnerable road users.