

An Integrated Driver-Vehicle-Environment (I-DVE) model to assess crash risks

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Outline

- Motivations
- Limitations of existing approaches
- Overview of I-DVE
- Simulation procedure
- Simulation results
- Conclusion



Why a model?

- Development of safety systems
 - Analyse/improve performance
 - Categorize/predict driver behaviour
 - Simulation
 - ...



What can be modeled?

- Driver
 - strategic, tactical (decision making), operational (eye movements)...
- Environment
 - traffic, pollution ...
- Vehicle
 - speed, car following pattern...



Limitations of current approaches

- Driving is a complex interaction between DVE
 - Behaviour depends upon the circumstances drivers perceive themselves to be in, at time t , $t+1$...
 - Non integrated modeling (DVE) to assess risks



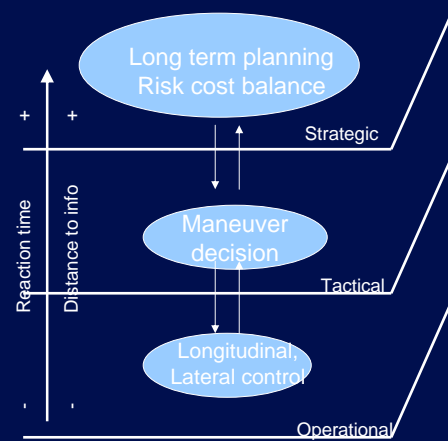
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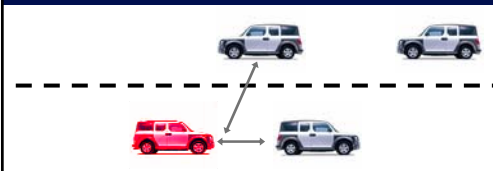
Overview I-DVE model

- Based on Michon (1985)
 - Strategic level
 - Long term planning
 - Risk cost balance
 - Tactical level
 - Manoeuvre decision
 - Execution parameter
 - Operational level
 - Longitudinal, lateral control



Estimating risk: rear end crashes

- The risk is modelled with three parameters:
 - driver's risk taking profile
 - probability of crash
 - crash severity.



$$\text{Risk} = P(\text{crash}) \times \text{Severity}$$

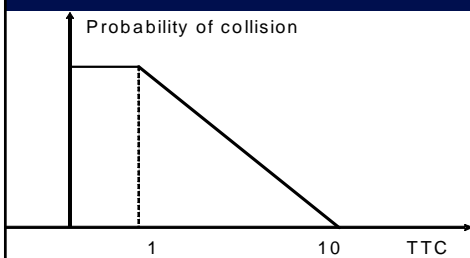
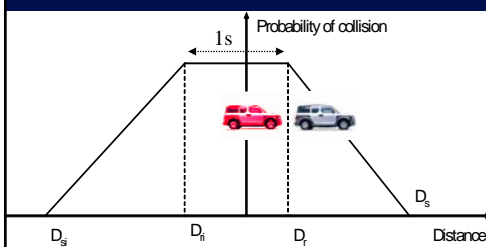


Risk function - driver profile

- Acceptable level of risk relative to the current “net” cost (LAVIA, Sauvagnac P. Olivero P (2002))
- Cost reflects balance between driver objectives and penalties



Modeling crash probability



- Inter vehicular distance
 - D_r : distance until the driver reacts ($D_r = T_r \cdot V$)
 - D_s : stopping distance
- Time To Collision (TTC)
 - 1s : reaction time,
 - 10s : max time react to stimuli (Prevent Project)

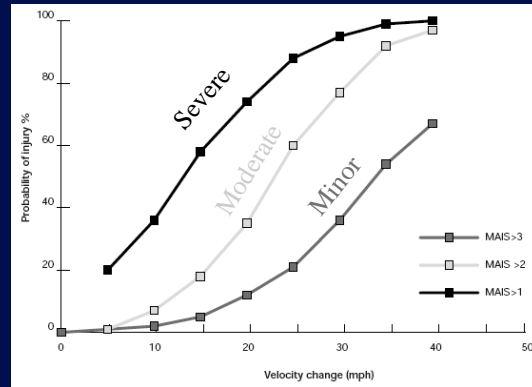


Modeling crash severity

- Equivalent Energetic Speed (EES)

$$\begin{cases} MV + M_i V_i = M\hat{V} + M_i \hat{V}_i \\ \frac{1}{2}MV^2 + \frac{1}{2}M_i V_i^2 = \frac{1}{2}M\hat{V}^2 + \frac{1}{2}M_i \hat{V}_i^2 \end{cases}$$

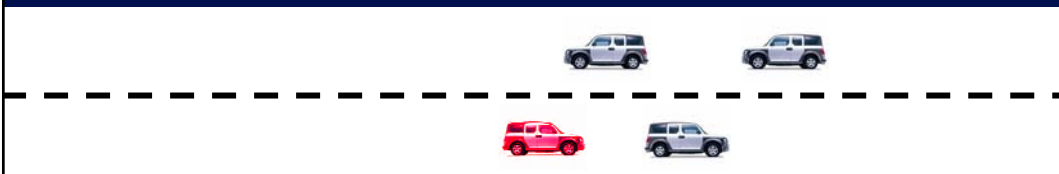
$$EES = \frac{2M_i}{M + M_i}(V_i - V)$$



MIAS: Maximum Abbreviated Injury Scale
Hobbs and Mills (1984).



Aim of the simulation

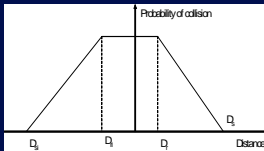


- Determine the safest speed which minimizes crash risks using
 - EES (Vehicle)
 - TTC (Environment)
 - Driver profile (Driver)

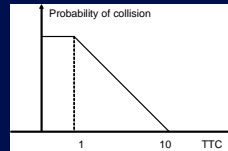


Simulation procedure in MatLab

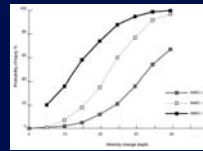
Relative position



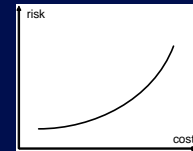
Relative Speed



EES, mass, MAIS



Driver's profile



Risk evaluation
for a given speed (situation)



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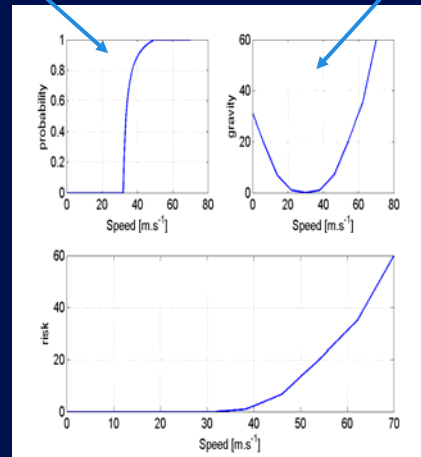


Optimal speed for vehicle following another

- The considered car is following another car
 - Speed: 30m/s
 - Distance: 20m
- Risky situation (low inter distance)
 - Good response at low speed
 - Good response at high speed

TTC

EES (MAIS>2)



Conclusion

- New integrated DVE model to assess risk
 - features strategic, tactical and operational layers (Michon,1985)
 - Estimates optimal risk per situation
 - Simulation data based on real situations
- Future: validation in an advanced driver simulator

