WORLD ROAD ASSOCIATION MONDIALE DE LA ROUTE
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DEVELOPMENT OF A PREDICTION MODEL FOR SPLASH AND SPRAY

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Contents

- The splash spray project
- Overview of the model
- Water depth model
- CFD model
- Summary and next steps

Background

- Road geometry and surface characteristics contribute to splash and spray
- No method suitable for widespread measurement
- Project will develop a tool to predict splash spray
- Outputs can contribute to decisions on highway maintenance
- Ultimately, to improve user satisfaction with the road network

Project partners

- 4 year project awarded by FHWA

Virginia Tech Transportation Institute

Gerardo Flintsch, Brian Williams

Ronald Gibbons, Lijie Tang

Virginia Center for Transportation Innovation & Research

Kevin McGhee

TRL

Helen Viner, Alan Dunford

Kamal Nesnas, Fiona Coyle

NTEC Nottingham Transportation Engineering Centre

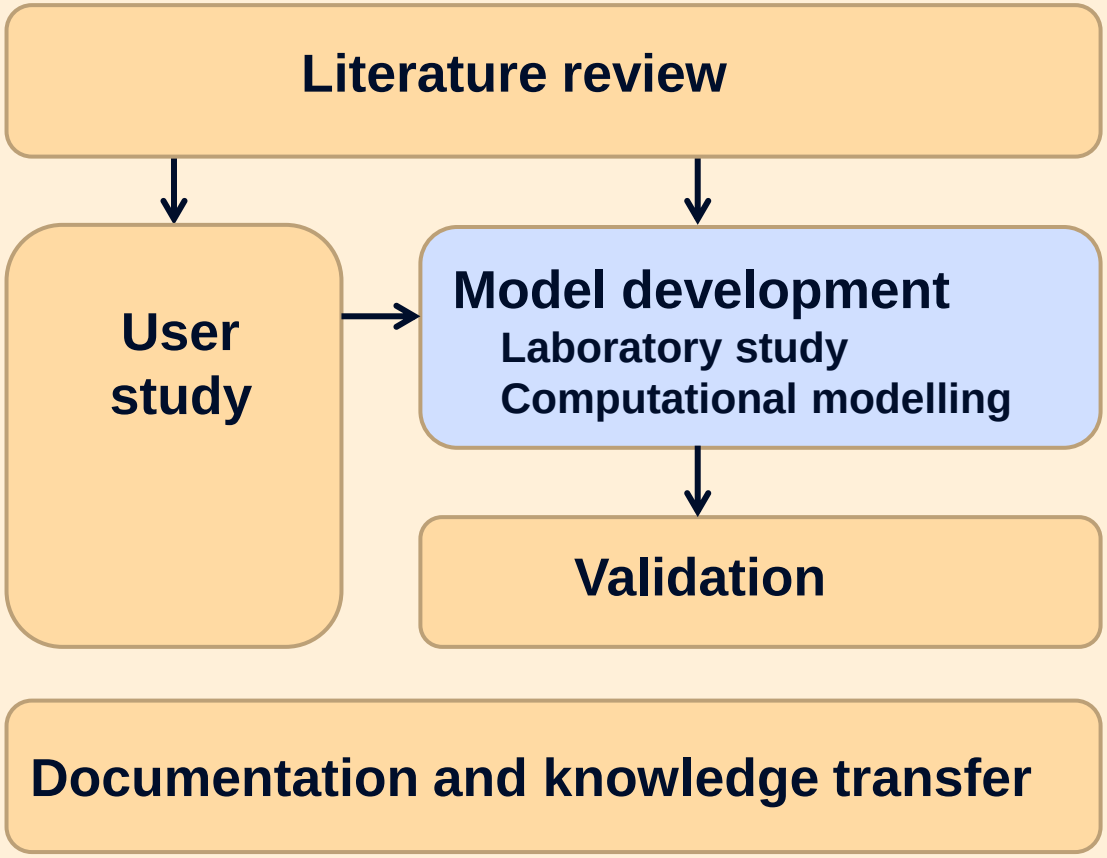
Tony Parry

David Hargreaves

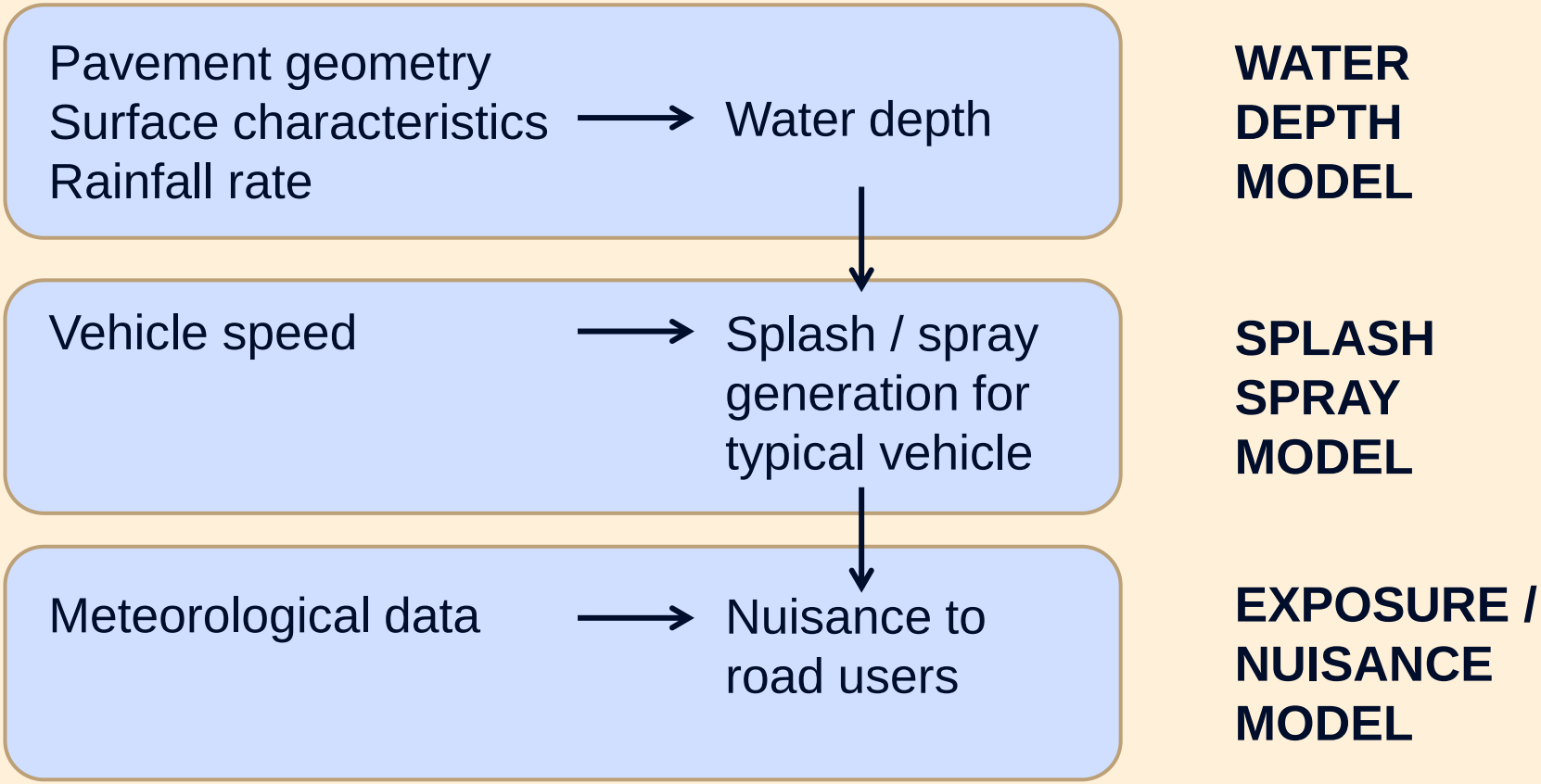
applied pavement technology

Roger Larson

Project overview



Vision for splash spray model



Water depth model

- Literature search found a number of equations predicting water depth
- Similar general form:

$$d = k\, T^w\, L^x\, I^y\, S^z$$

Where

T = texture depth

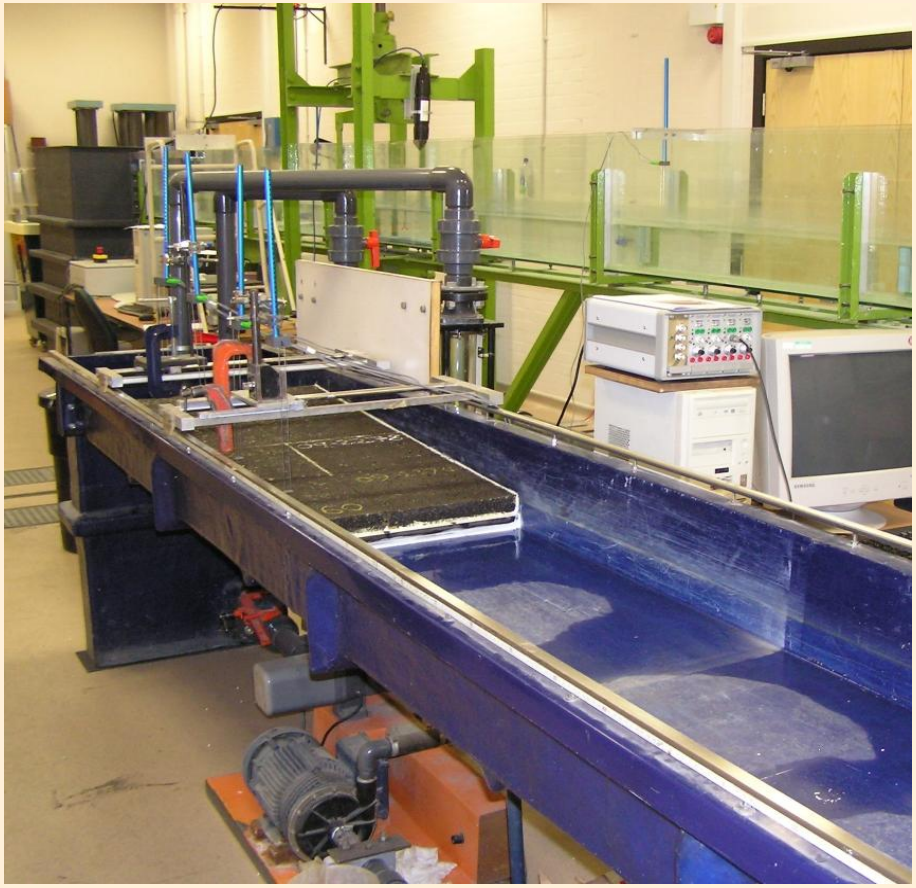
L = drainage length

I = rainfall rate

S = slope

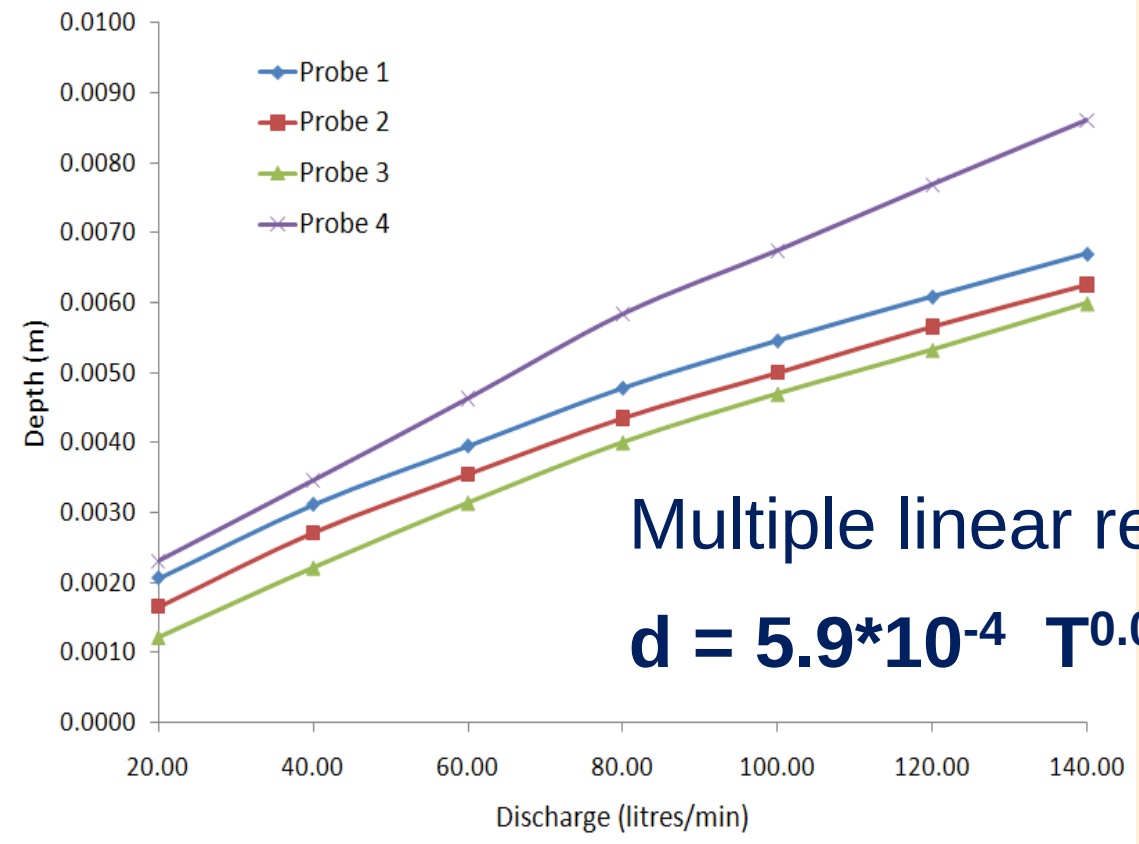
- Values of k, w, x, y, z to be determined through experimentation on relevant range of surfaces

Flume experiment



Surface type	Texture depth (mm MPD)
Stone Mastic Asphalt	0.55
Asphaltic concrete	0.63
Smooth concrete	0.21
Tined concrete	1.01
Open graded friction course	1.64
Perspex	0.001

Flume experiment - results

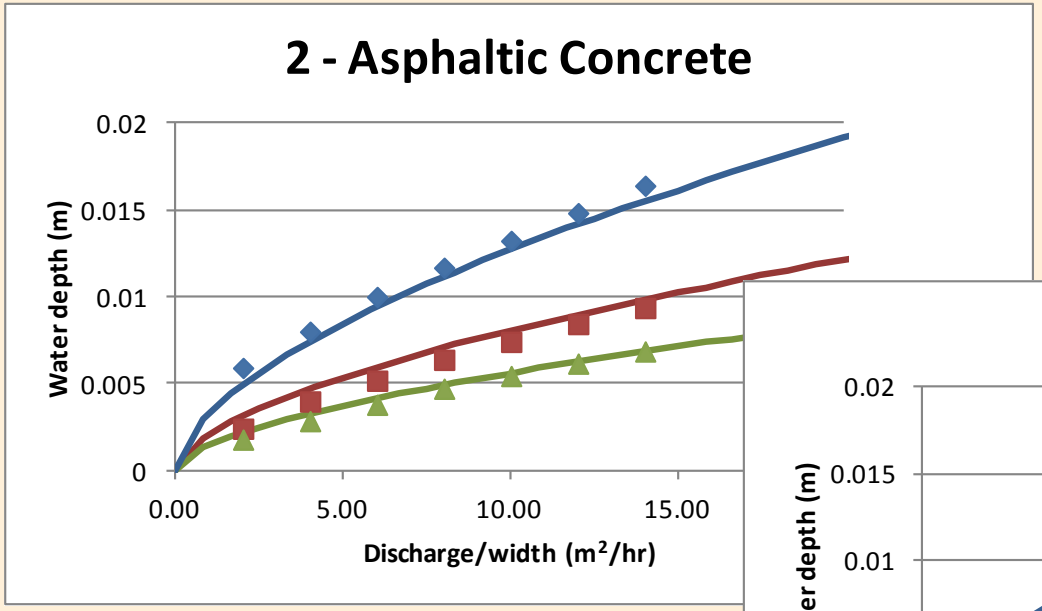


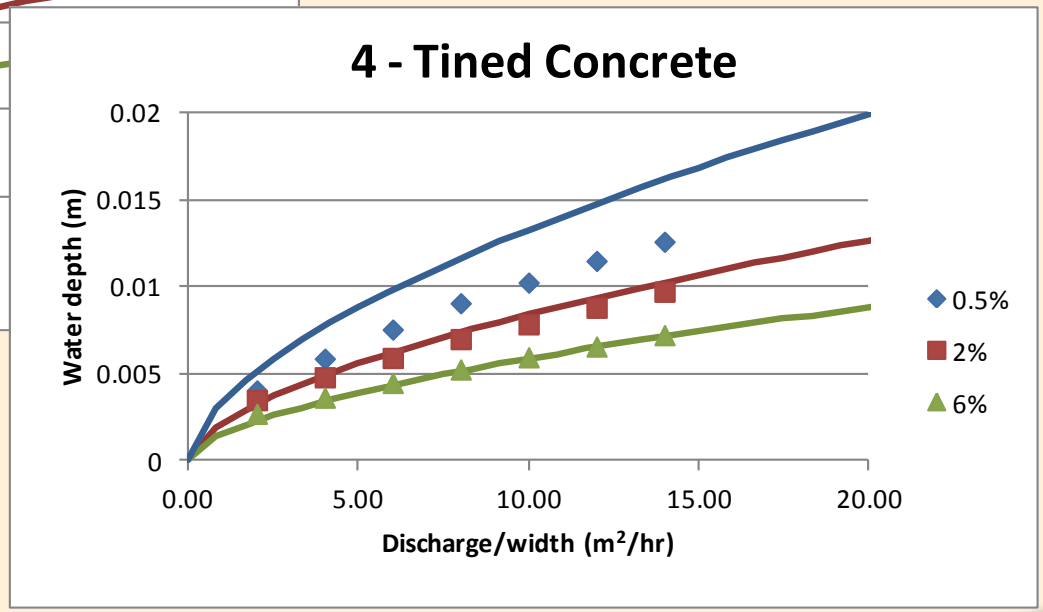
Example data set from one surface at one slope

Multiple linear regression of the data

$$d = 5.9*10^{-4}\ T^{0.087}\ (LI)^{0.59}\ S^{-0.33}$$

Flume experiment - results





Splash/spray model

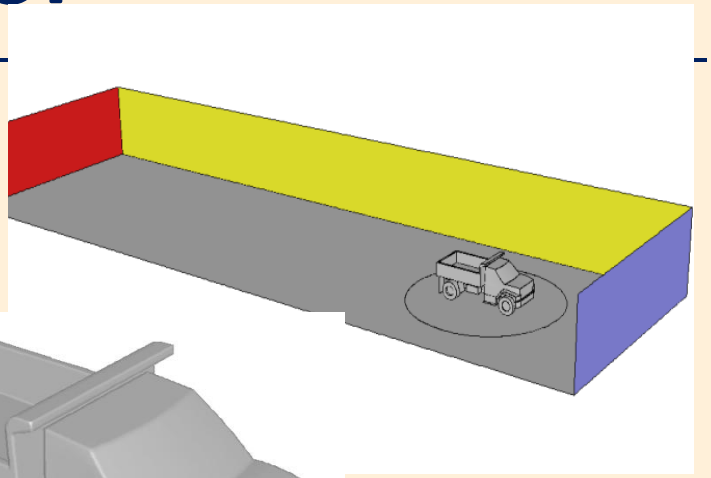
- Predicts how a given depth of water translates into a level of user nuisance
- Used computational fluid dynamic (CFD) modelling approach
- Truck travelling at given speed will displace a given volume of water per unit time
  - Where does it go?
  - How much of it causes nuisance to road users?

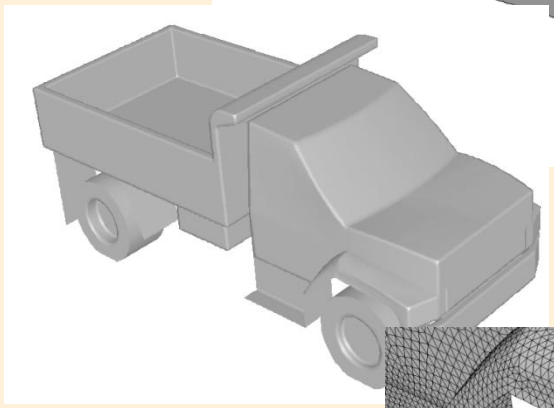
Relevant findings from user study

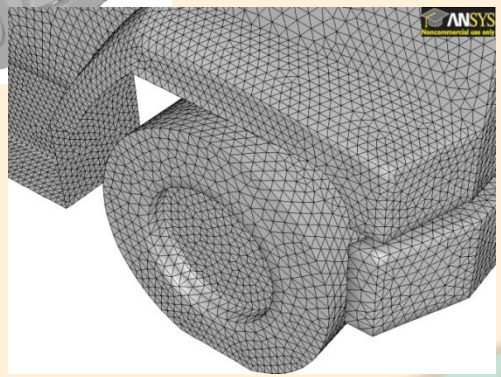
- Greater degree of nuisance reported:
  - When following rather than passing
  - For dump truck rather than tractor-trailer
  - From viewpoint of sedan rather than SUV
- **Occlusion** correlates well with all measures of user perception

Overview of CFD model

- CFD model consists of a dump truck and sedan car within a rectangular tube
- A turbulent air stream passes through this
- Overall velocity of the air stream chosen to represent the desired truck velocity
- (Truck remains stationary)







Water droplets released into turbulent air field

Draws heavily on the Weir model for generation of splash and spray

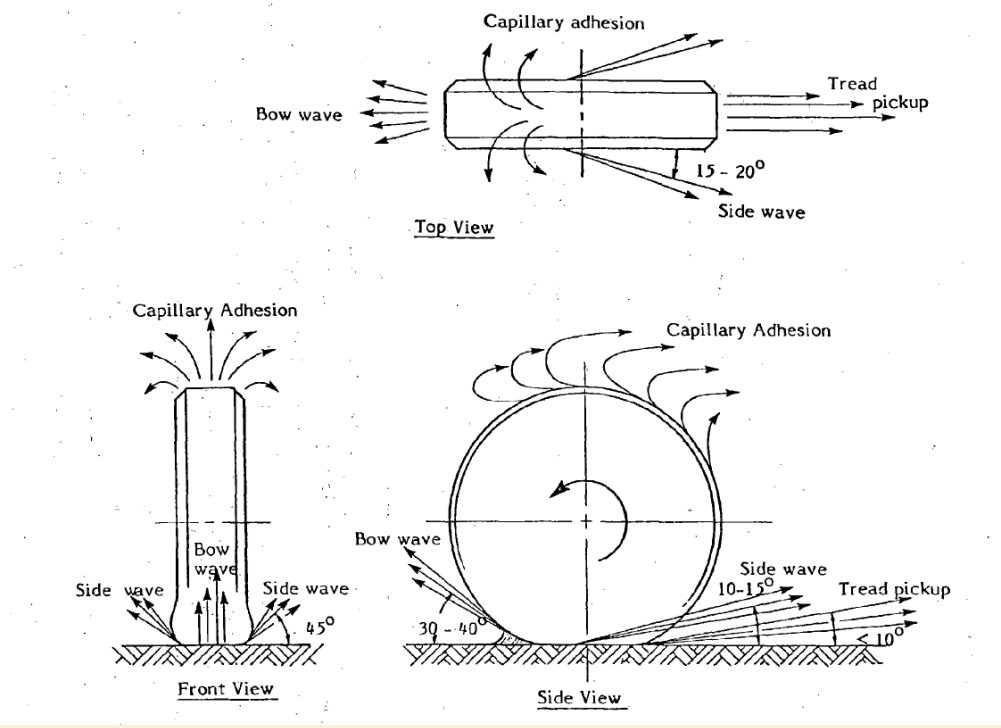
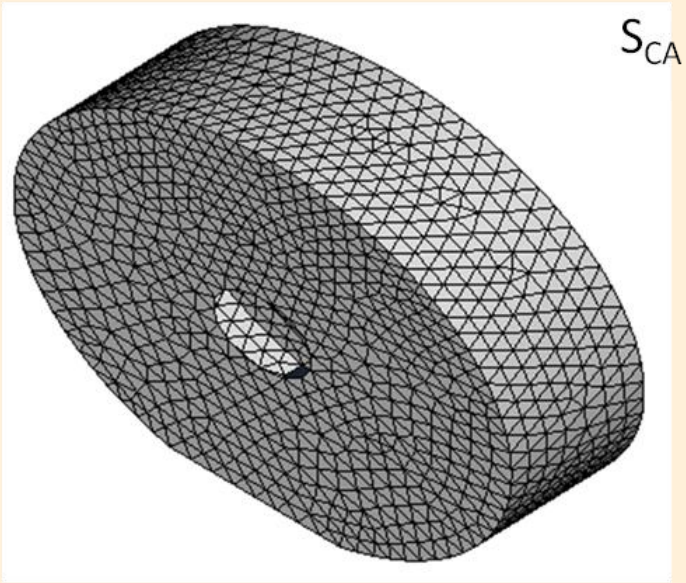


Diagram reproduced from Weir (1978)

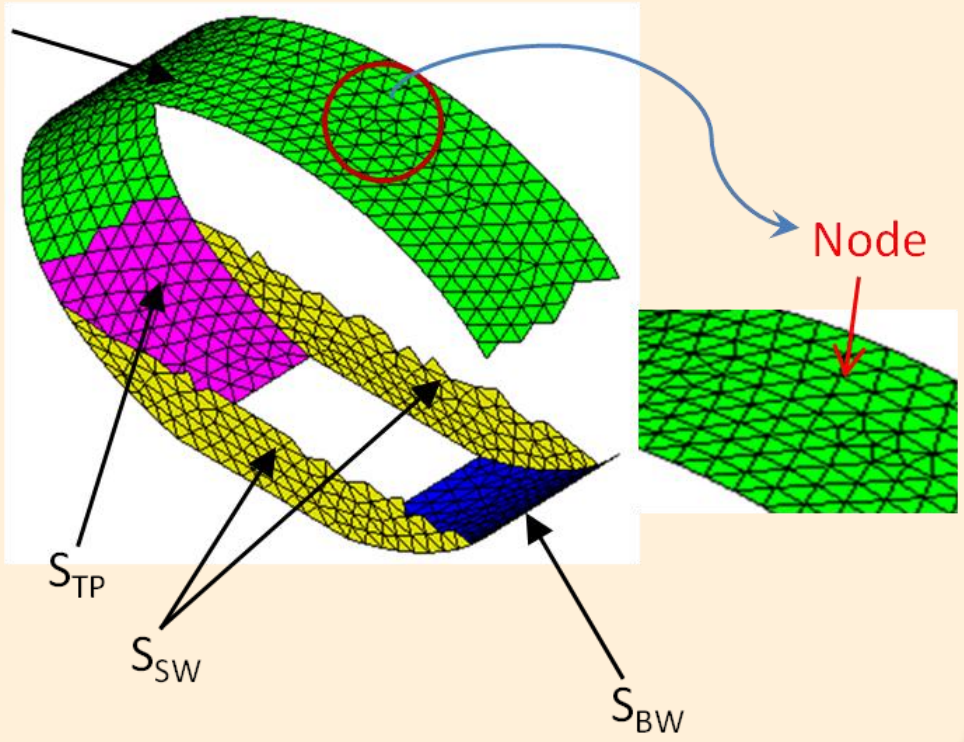
- Capillary adhesion
- Tread pickup
- Bow wave
- Side wave

Droplet starting positions and velocities in CFD

Front wheel

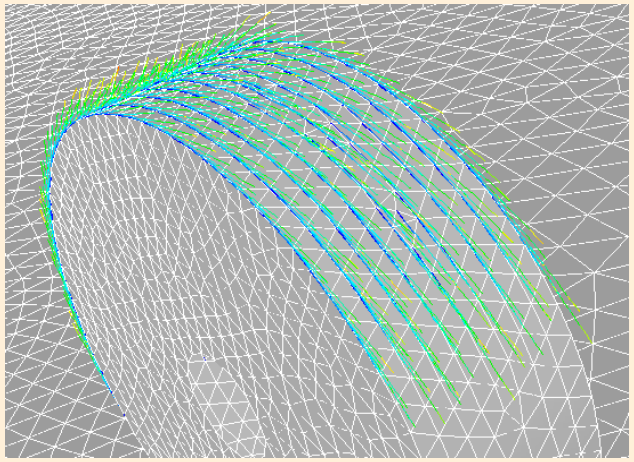


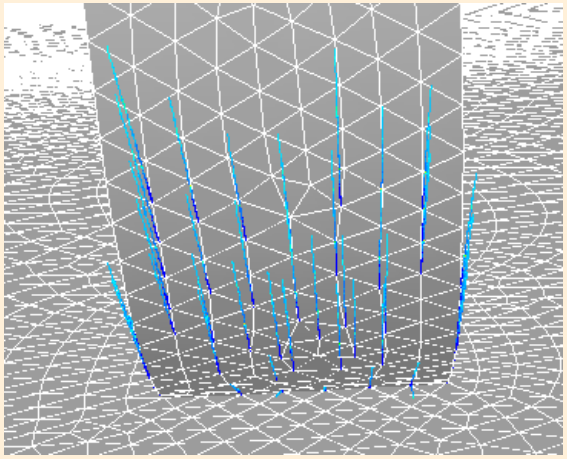
Surfaces (S) for droplets release



Droplet starting positions and velocities in CFD

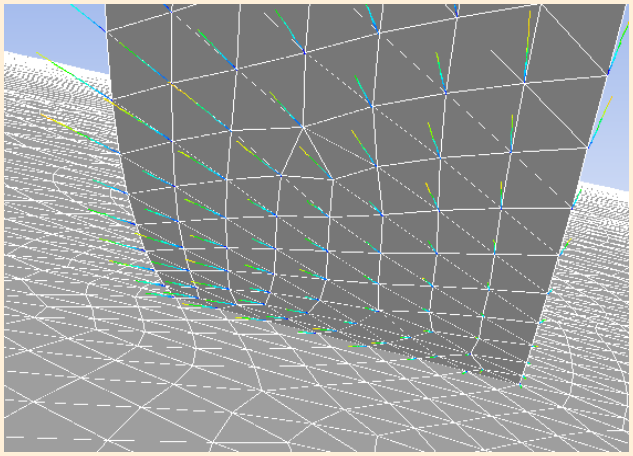
Capillary adhesion

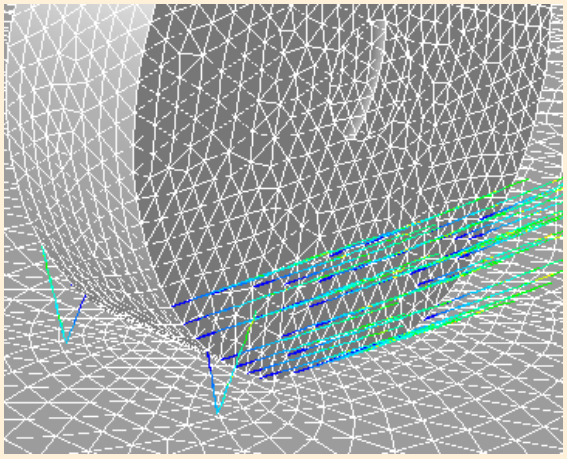




Tread pickup

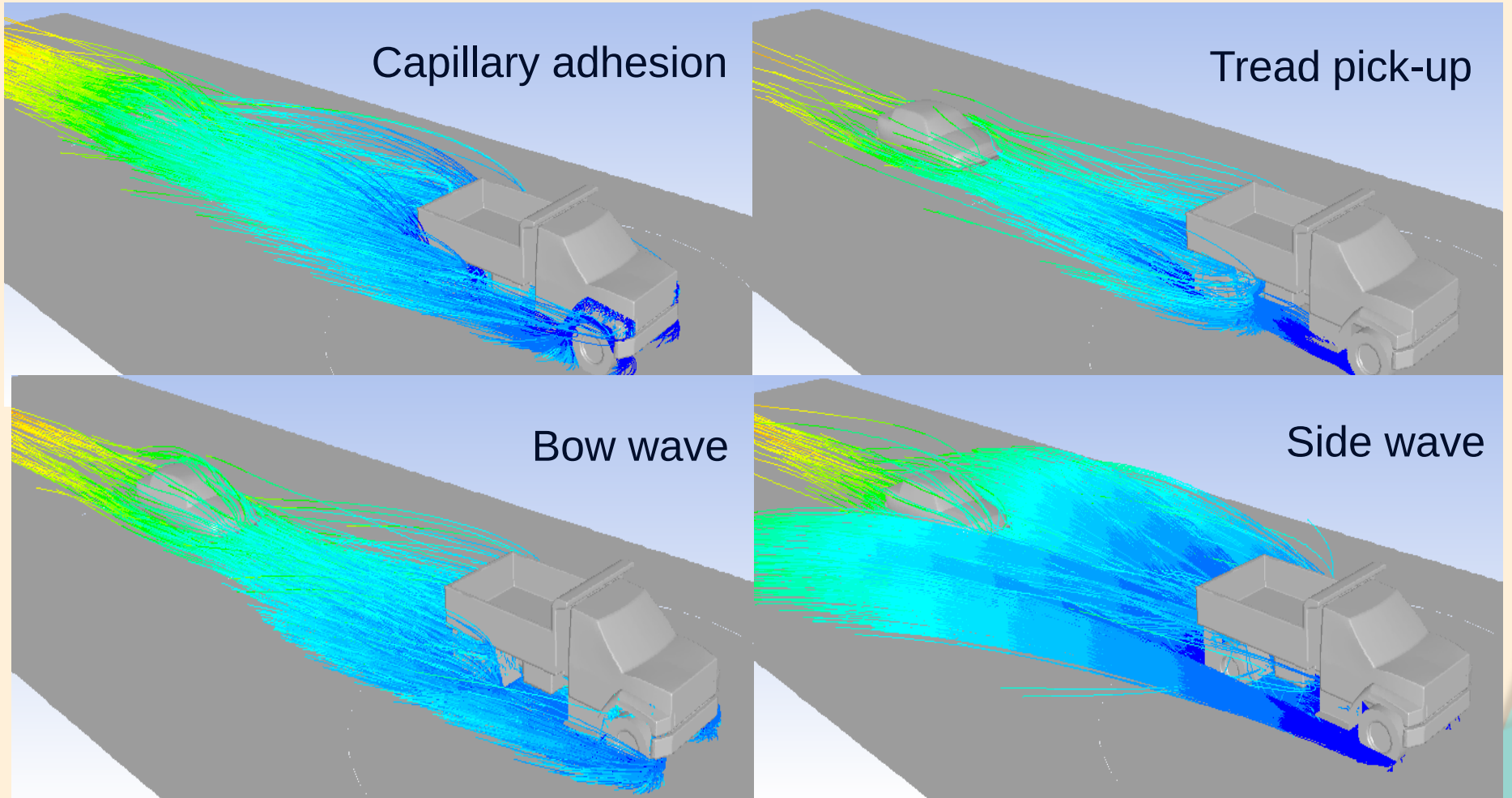
Bow wave





Side wave

CFD for individual splash/spray mechanisms

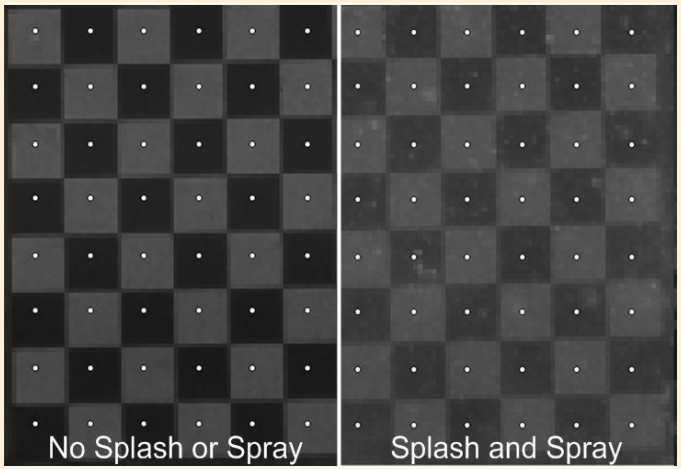


Splash/spray model – next steps

- We have defined a measure of user nuisance
  (the volume of water within the height of the windscreen, between the sedan and truck)
- From CFD runs, will quantify user nuisance per unit water as a function of vehicle speed, for each mechanism
- From water depth (from exposure model) and vehicle speed, will estimate the mass flow rate of water for each mechanism
- Combine estimate of nuisance for the 4 mechanisms to determine the overall nuisance (adjust proportions based on validation study)

Splash/spray model – next steps

- Model will be implemented in a speadsheet
- This will enable the nuisance to road users from splash spray to be determined from data input by the user:
  - Road geometry
  - Pavement surface texture
  - Meteorological data



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