Rail Technology Unit

Manchester Metropolitan University

Rail Research UK

Vehicle Dynamics in A5:

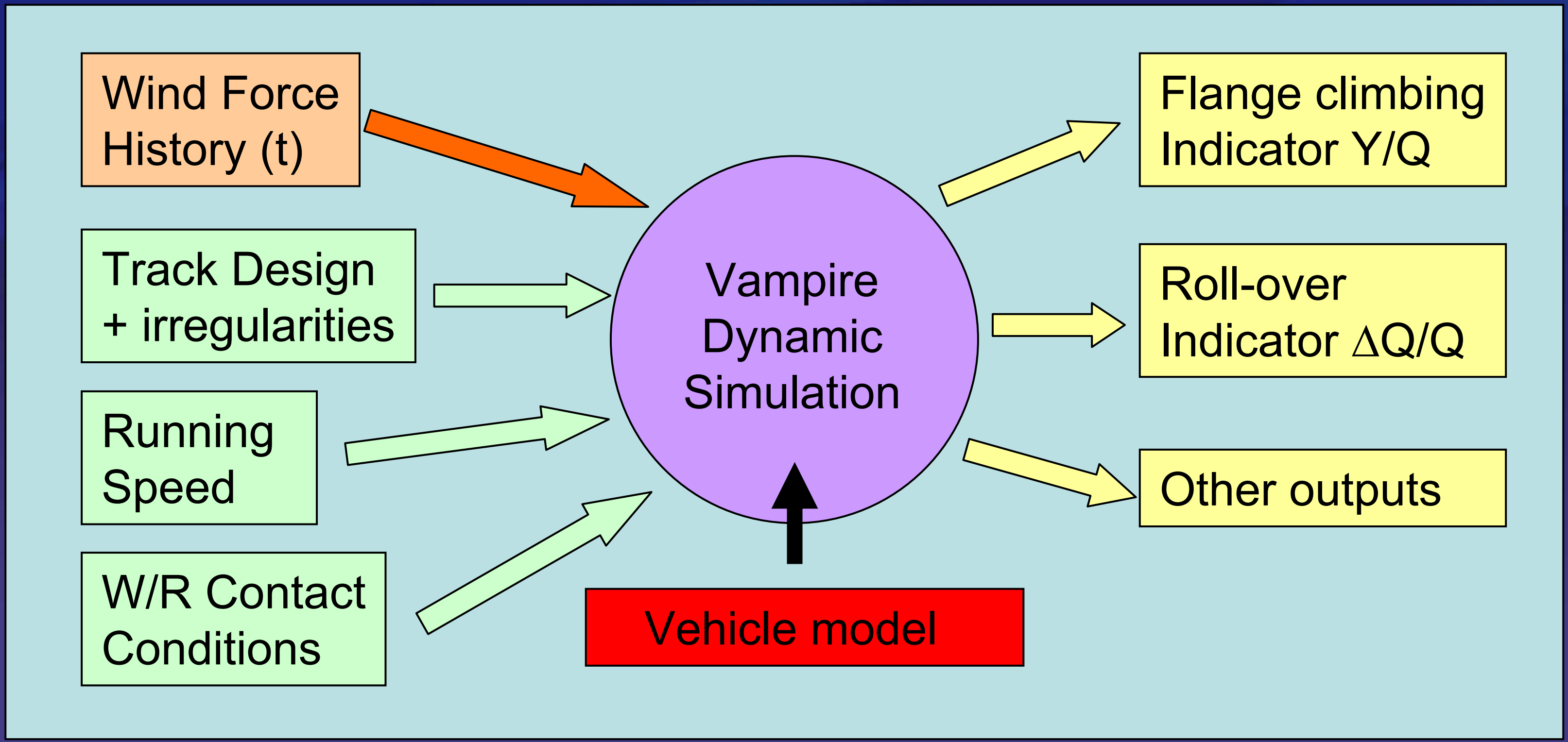
- Integration of ***aerodynamic*** and ***wheel-rail*** forces in Vampire
- Simulation scenarios for ***flange climb*** and ***roll over*** risk:
  - *Study of main factors: curvature and cant, vehicle speed, wind speed, track irregularities*
  - *Selection of appropriate scenarios*
- Risk assessment by simulation under continuous wind
- Risk assessment by simulation with sudden application of wind forces
- Conclusions and future work

Rail Research UK

- Integration of ***aerodynamic*** and ***wheel-rail*** forces in Vampire
- Simulation scenarios for ***flange climb*** and ***roll over*** risk:
  - *Study of main factors: curvature and cant, vehicle speed, wind speed, track irregularities*
  - *Selection of appropriate scenarios*
- Risk assessment by simulation under continuous wind
- Risk assessment by simulation with sudden application of wind forces
- Conclusions and future work

Integration of aerodynamic Forces into Vampire

Rail Research UK



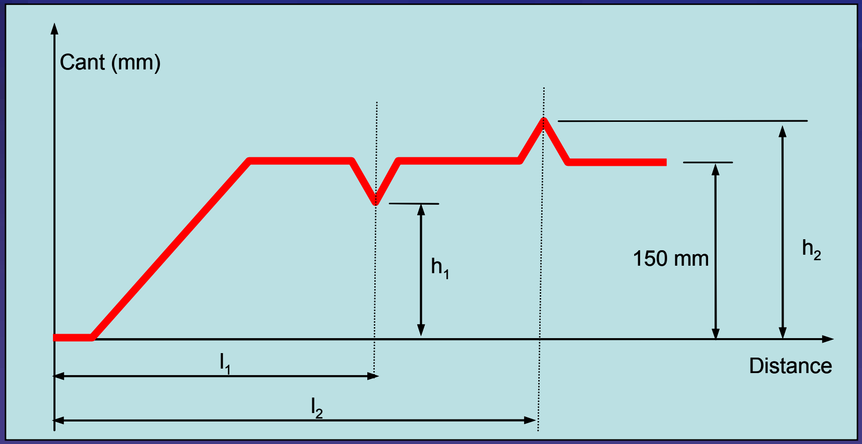
- Integrate all forces that affect the dynamic behaviour of the vehicle
- Produce time history of vehicle behaviour under the effect of wind in various running conditions
- Assess risk of derailment under these conditions

- Integration of ***aerodynamic*** and ***wheel-rail*** forces in Vampire
- Simulation scenarios for ***flange climb*** and ***roll over*** risk:
  - *Study of main factors: curvature and cant, vehicle speed, wind speed, track irregularities*
  - *Selection of appropriate scenarios*
- Risk assessment by simulation under continuous wind
- Risk assessment by simulation with sudden application of wind forces
- Conclusions and future work

Simulation scenarios

- Track curvature: *R=1000m, R=500 m*
- Speed: *150 mm cant deficiency, 100 mm cant excess*
- Track twist: *Two track twist conditions 1:126 and 1:91*

  (from NR maintenance limits)



- Vehicle: *class 365 EMU*
- Intensity of wind: *none, average (10m/s), strong (15 m/s) and extraordinary (22 m/s)*
- Nature of wind: *continuously applied, suddenly applied*

Derailment modes

Rail Research UK

Wind load added:
- outwards with cant deficiency
- Inwards with cant excess

Wheel forces calculated:

Vertical force at each wheel (Q)

Lateral force at each wheel (Y)

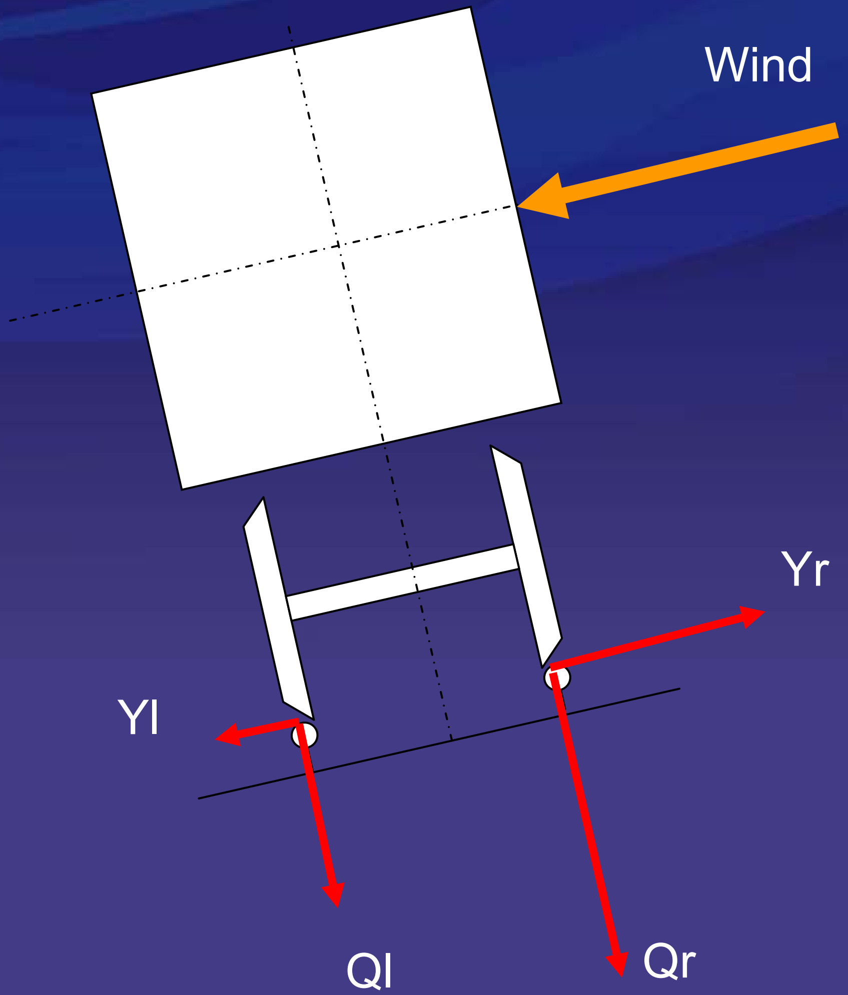
For Rollover derailment

DQ/Q >1

For Flange Climbing derailment

Y/Q > 1.2

(For any wheel)

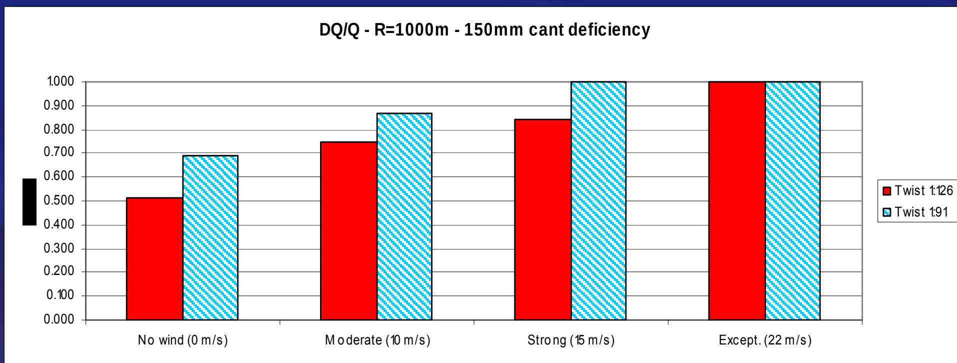


- Integration of ***Aerodynamic*** and ***wheel-rail*** forces in Vampire
- Simulation scenarios for ***flange climb*** and ***roll over*** risk:
  - *Study of main factors: curvature and cant, vehicle speed, wind speed, track irregularities*
  - *Selection of appropriate scenarios*
- Risk assessment by simulation under continuous wind
- Risk assessment by simulation with sudden application of wind forces
- Conclusions and future work

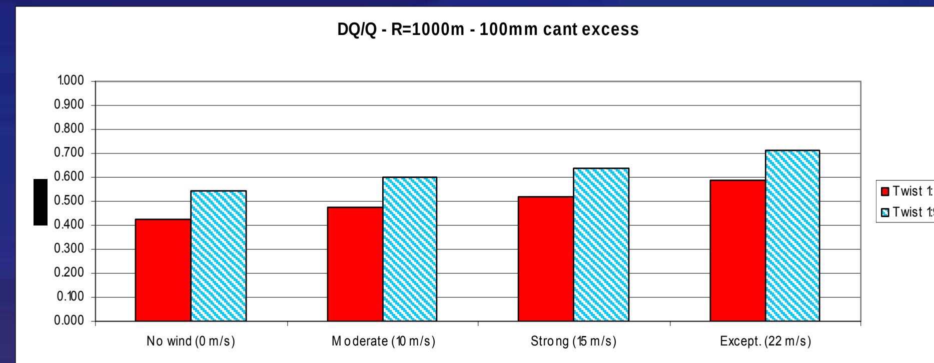
Results – Continuous wind – Cant Excess v Cant Deficiency

Rail Research UK

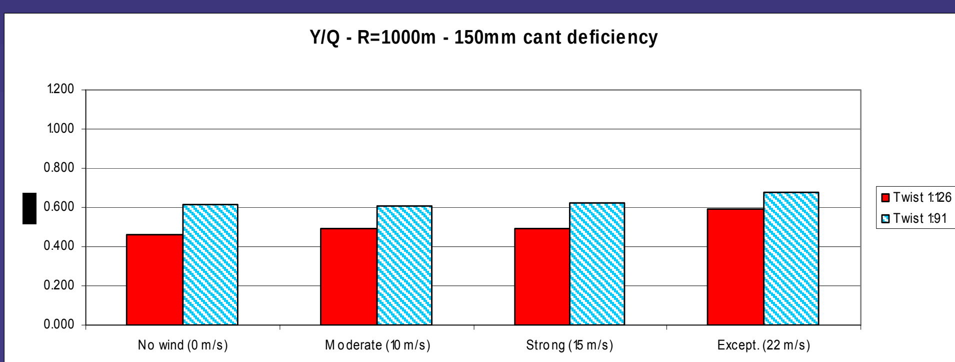
Cant deficiency – Roll over



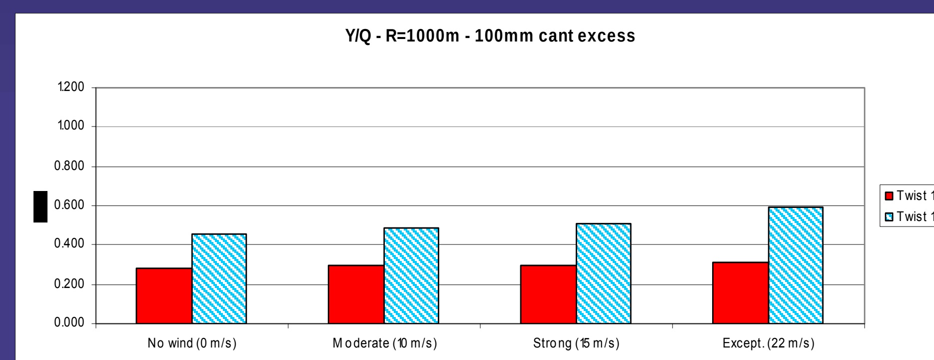
Cant excess – Roll over



Cant deficiency – Flange climbing



Cant excess – Flange climbing

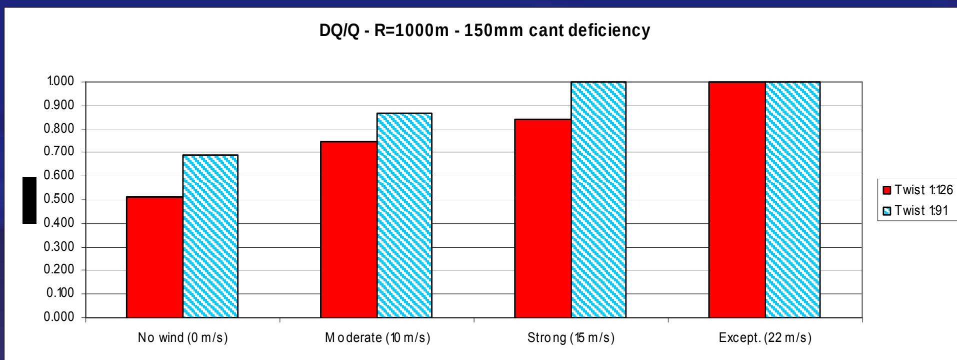


- Conclusion: risk highest with cant deficiency

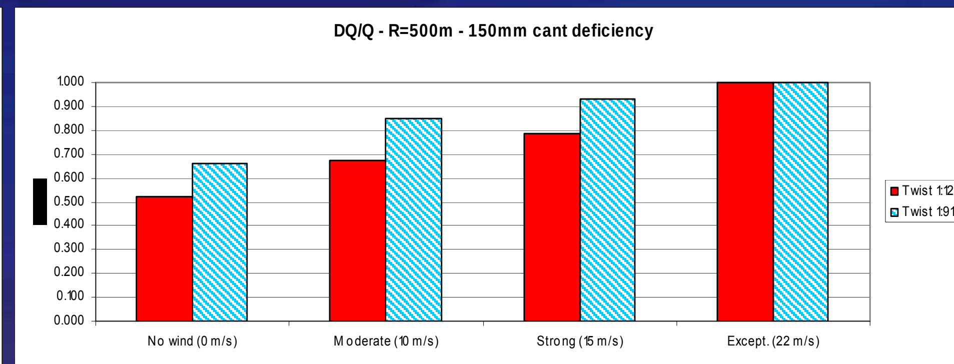
Results – Continuous wind – Higher curvature v Higher speed

Rail Research UK

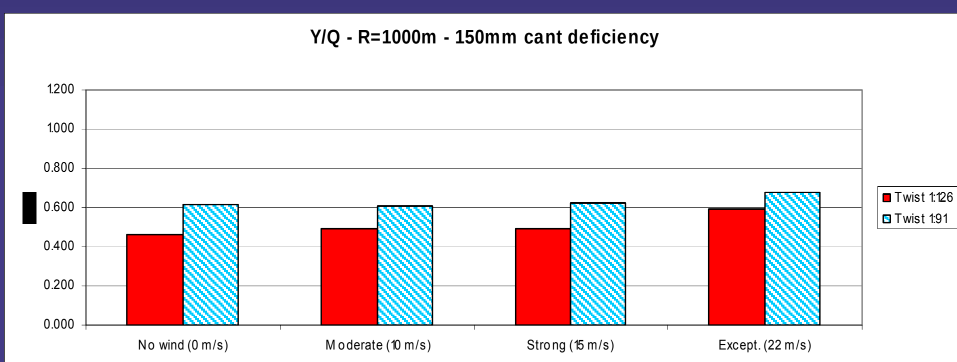
R=1000 m – 100 mph – Roll over



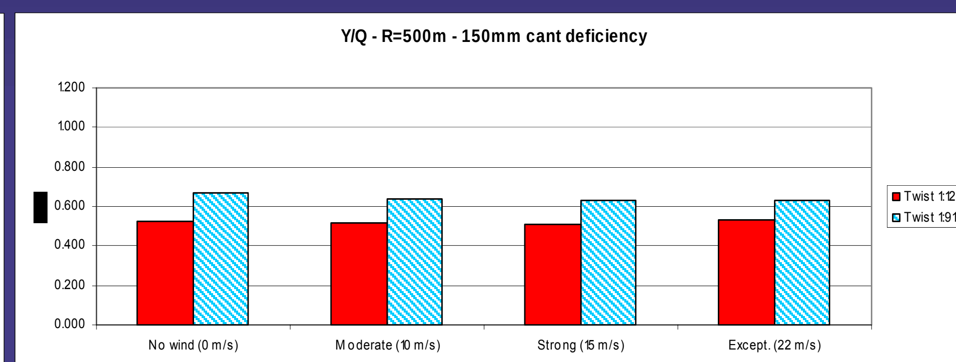
R=500 m – 70 mph - Roll over



R=1000 m – 100 mph - Flange climbing



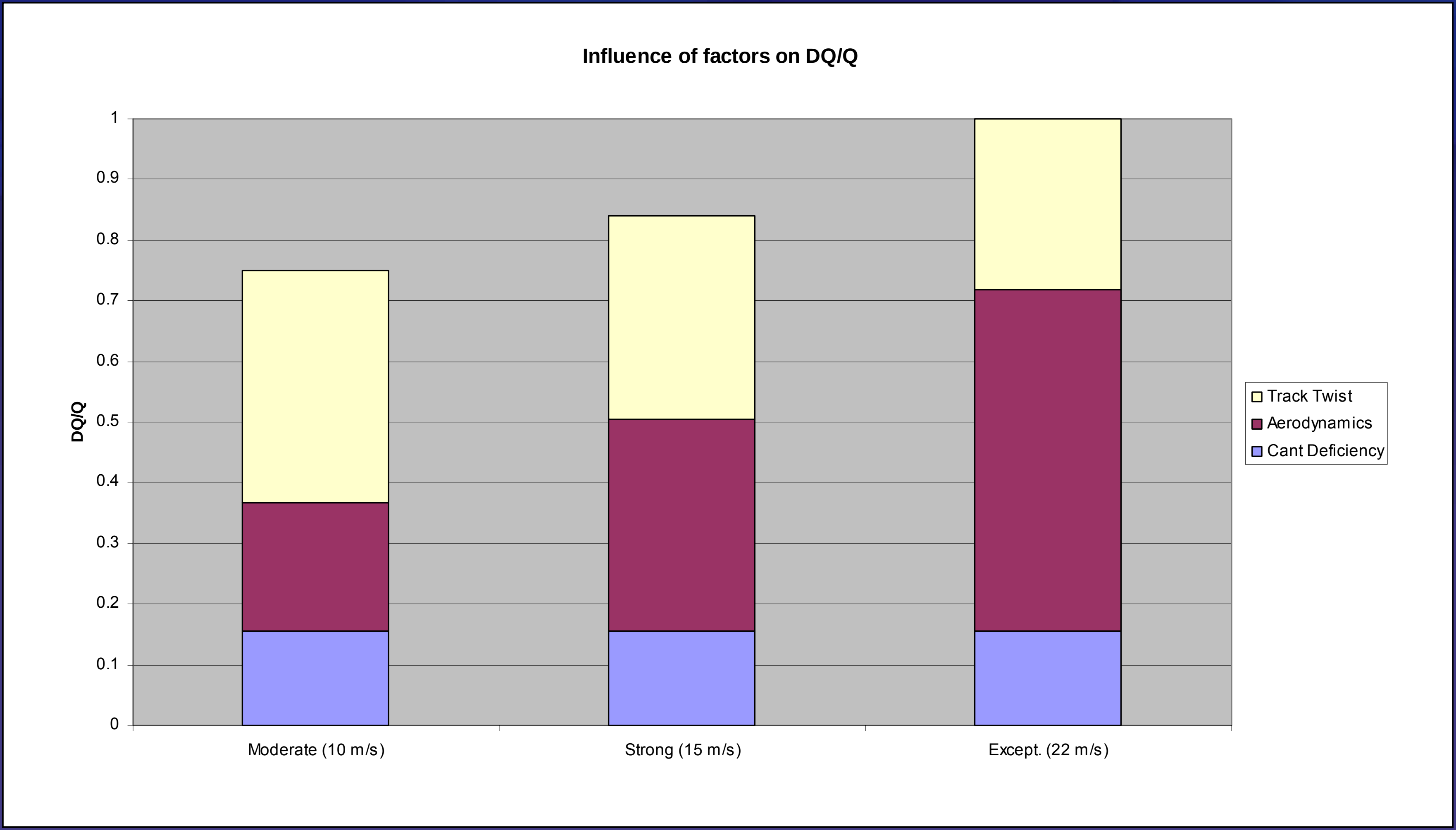
R=500 m – 70 mph - Flange climbing



- Conclusion: Higher speed/lower curvature more risk

Results – Continuous wind
Effect of cross wind forces

Rail Research UK



R=1000 m, speed = 100 mph, cant deficiency = 150mm, twist = 1:126

Results – Continuous wind Conclusions

Rail Research UK

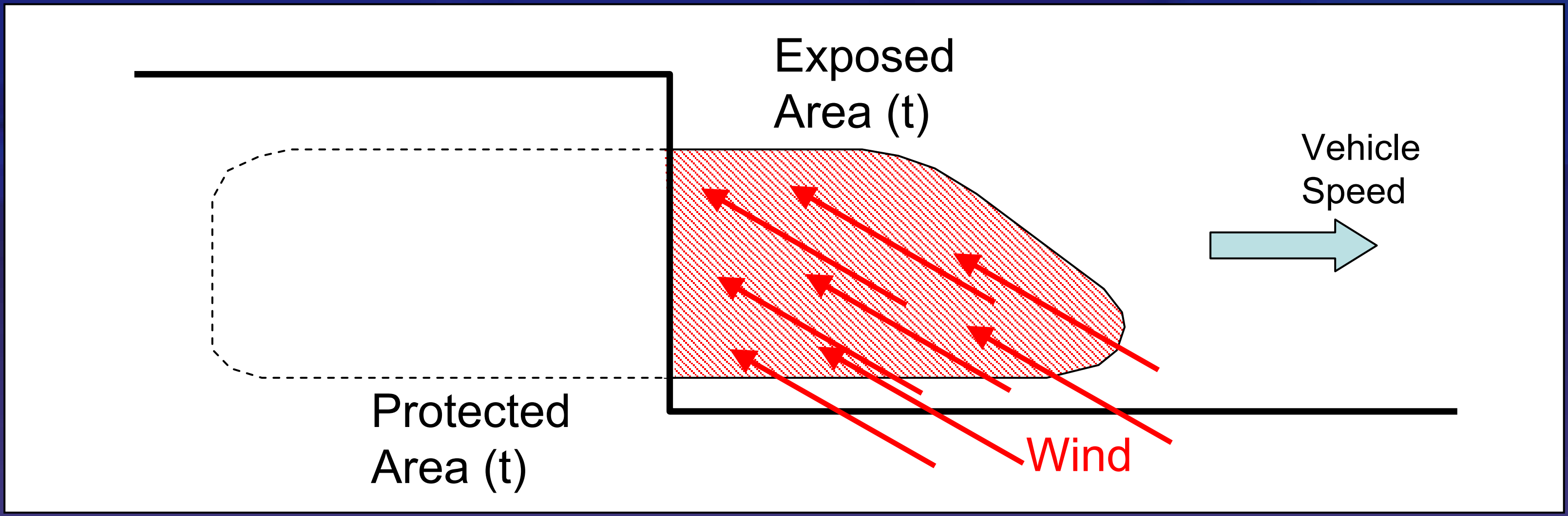
- Risk is highest with cant deficiency
- Speed shows a bigger effect than curvature
- Therefore, the most dangerous scenario corresponds to:
  - *High cant deficiency*
  - *High speed*
  - *(Therefore) Shallow curves*
- Roll-over is the dominant derailment mechanism (in the presence of cross winds)

Rail Research UK

- Integration of ***Aerodynamic*** and ***wheel-rail*** forces in Vampire
- Simulation scenarios for ***flange climb*** and ***roll over*** risk:
  - *Study of main factors: curvature and cant, vehicle speed, wind speed, track irregularities*
  - *Selection of appropriate scenarios*
- Risk assessment by simulation under continuous wind
- Risk assessment by simulation with sudden application of wind forces
- Conclusions and future work

Methodology for force calculation with Sudden wind

Rail Research UK

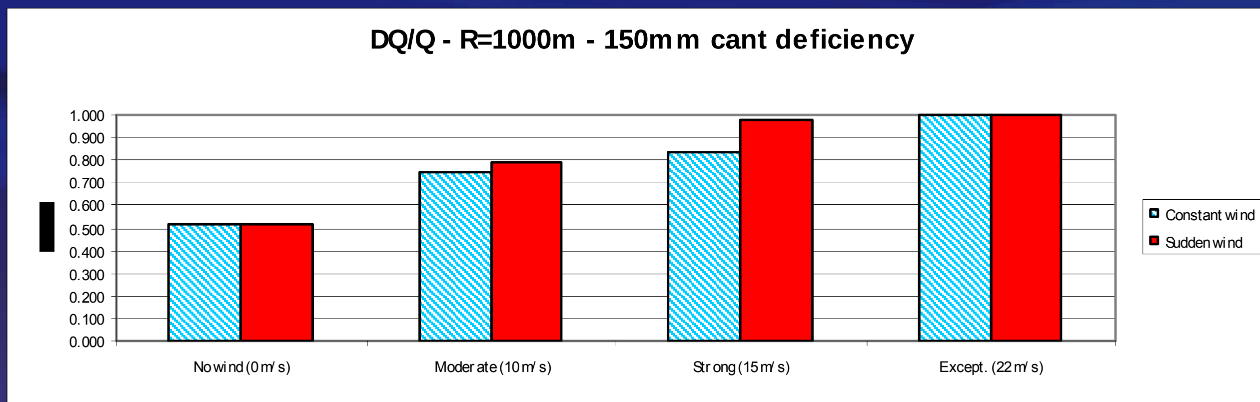


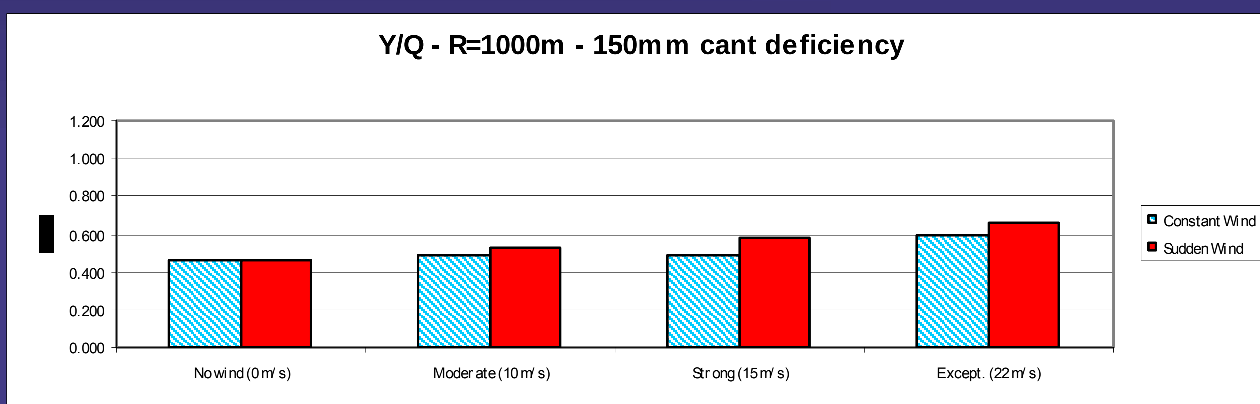
- Varying exposed area
- Application point is not centred $\Rightarrow$ instantaneous torques are generated around CoG

Sudden wind Vs continuous wind Comparison

Rail Research UK

- *R=1000 m, Speed = 100 mph, 1:126 track twist*





- Up to around 15% increase over continuous wind

Rail Research UK

- Integration of ***Aerodynamic*** and ***wheel-rail*** forces in Vampire
- Simulation scenarios for ***flange climb*** and ***roll over*** risk:
  - *Study of main factors: curvature and cant, vehicle speed, wind speed, track irregularities*
  - *Selection of appropriate scenarios*
- Risk assessment by simulation under continuous wind
- Risk assessment by simulation with sudden application of wind forces
- Conclusions and future work

Summary and conclusions

Rail Research UK

- Scenarios defined to evaluate risk of derailment under cross winds
- A method for accounting for sudden exposure to the wind developed
- Higher risk identified for roll-over derailment mechanism than for flange climbing
- The wheel unloading values obtained show an actual risk of rolling over in extraordinary, but still realistic situations
- Most dangerous conditions appear to be on shallow curves with high cant deficiency due to:
    - Higher aerodynamic forces at higher vehicle speeds
    - Higher dynamic effects from track irregularities at higher speeds

Next steps …

Rail Research UK

- Extend to more complex track cases
  - Run on real track irregularities
  - Detect and study dangerous track features
- Extend to further vehicles
  - Class 390? …..
- Assess existing vehicle acceptance standards
  - Develop limit cases to explore how well existing standards cope with the effect of cross wind
- Evaluate gauging implications of wind forces
  - Include wind in the dynamic gauging simulations
  - Evaluate increase of displacement at the gauging points