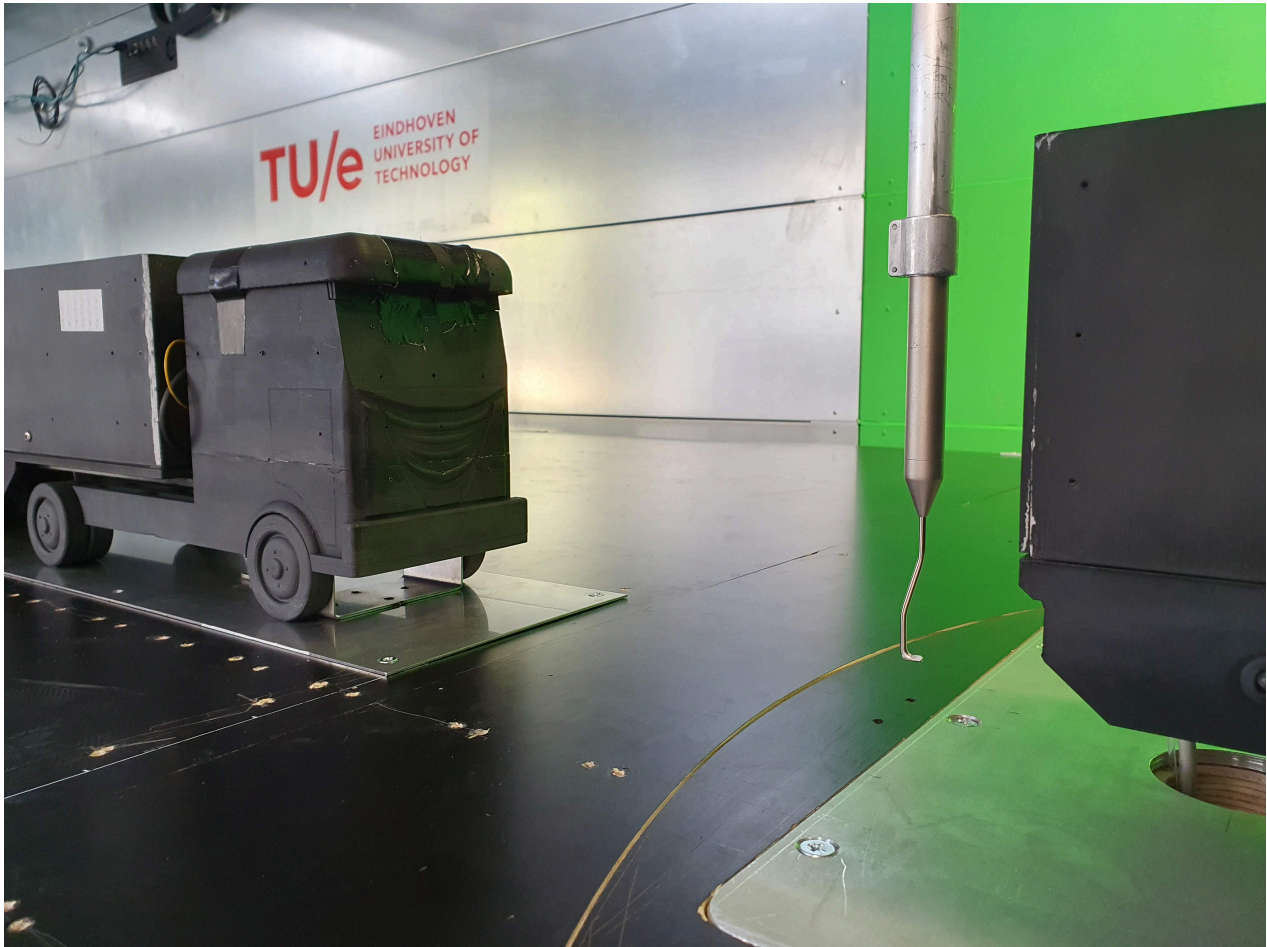


Metadata Report



Project Name

The aerodynamics of platooning and overtaking vehicles

Period

2023-2024

Dataset Description

A series of experiments was conducted in the closed-circuit Atmospheric Boundary Layer Wind Tunnel at Eindhoven University of Technology, featuring up to three Heavy Ground Vehicle (HGV) models at a reduced geometric scale of 1:20. The aim of this test was threefold. First, surface pressure and wind loads were investigated on an isolated HGV model for various crosswind conditions (yaw angles of 0° - no crosswind, 15° , 30° and 45°). Second, three HGV models were arranged in a platoon formation and the effect on surface pressures and wind loads of aforementioned crosswind conditions was studied on the platoon. Wake flow characteristics were assessed for the platoon at a yaw angle of 0° . Third, the three HGVs were also used to simulate an overtaking manoeuvre by iteratively moving the first and third

model to mimic scenarios that are likely to occur while one HGV overtakes another. In total 44 configurations were assessed for the overtaking manoeuvre, for which surface pressure and wind loads were monitored.

Project Domain

Wind

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Focus Area(s)

Vehicle aerodynamics, Aerodynamic forces, Wind pressures, Velocity distribution / Flow field

Keywords

Aerodynamic loads, Surface pressures, Wake flow, HGV, Platoon, Overtaking, Road safety, Wind tunnel experiment

GEM taxonomy

Specimens

Specimen 1. Isolated HGV

The closed-circuit Atmospheric Boundary Layer Wind Tunnel at Eindhoven University of Technology with a cross-section of 3 m width and 2 m height was used to conduct a series of experiments on an isolated HGV model. The HGV model is based on the DAF XF lorry with a European type trailer configuration and was 3D printed out of polylactic acid, at a scale of 1:20th. A schematic of the HGV and corresponding

reduced-scale sizes are shown in pictures below. 106 pressure taps have been distributed over the surface of the vehicle, allowing connection to on-board pressure transducers, data loggers and a reference pressure box. To minimise the impact of the boundary layer formation over the upstream wind tunnel floor on measured results, a suspended ground plane (splitter plate) was installed 3 m downstream of the wind tunnel inlet, at a height of 0.3 m above the ground, with a width of 2.5 m and 5 m in length. The splitter plate included a turn table (1 m in diameter) whose centre was 1.875 m from the leading edge. The HGV model was placed on that turn table and connected by means of a central pin to a load cell underneath the splitter plate. To measure wind loads, the wheels of the HGV were hovering above the turn table floor by 1 mm.

Experiment 1. Experiment: Yaw angle effects on surface pressures and wind loads

A reference wind speed (U_{ref}) of 25m/s was applied and measured with a Pitot tube located in the free stream above the suspended ground plane. The resulting Reynolds number, based on U_{ref} and the model height is about 3×10^5 . After waiting 30 seconds for U_{ref} to stabilise, three repetition measurements (surface pressures and wind loads) of 60 seconds each were taken. The wind tunnel was then stopped, and the turn table was manually rotated to a new crosswind configuration. The crosswinds investigated were 0° (no crosswind), 15° , 30° and 45° . The model hosts 56 pressure transducers within the vehicle. To measure surface pressures at all 106 locations, the previously described measurement procedure was repeated after having re-arranged the on-board pressure transducers to cover the remaining pressure tap locations. To present results independent from differences in temperature, atmospheric pressure and relative humidity that may have occurred during the measurement period such parameters were monitored throughout the measurements.

Instrumentation

The load cell (type 6A40) employed was a six component Interface force balance with a range of 50 N in x and y and 200 N in z. The vehicle was mounted on the load cell in such a way that the x-direction was always aligned with the centre line of the HGV. The load cell sampled every 0.1 s. Each HGV model houses four data loggers assembled from Arduino Mega 2560 platforms and PCBs, with connections to 14 FirstSensor pressure transducers of type HCLA12x5PB and HCLA0025PB). Thus, a total of 56 pressure transducers. A reference pressure box inside the HGV model was used for static reference pressure measurements. The pressure data was sampled at 3 kHz and was saved to microSD cards. An iBTHX-W sensor from Omega Engineering was used to monitor ambient conditions at a frequency of 10 Hz.

Experiment 2. Experiment: Approach flow characterisation

Approach flow characteristics were measured at three streamwise distances: (1) 0.2 m upstream of the leading edge of the splitter plate, (2) 0.3375 m downstream of the splitter plate's leading edge, and (3) 1.4625 m downstream of the leading edge. For those measurements, the HGV models were not present. Vertical height profiles were obtained at the respective locations and lateral homogeneity of approach flow conditions was also assessed.

Instrumentation

A pitot tube located in the free stream above the suspended ground plane to measure the reference velocity (U_{ref}). A Series 100 Cobra probe (a four-hole pressure probe) from Turbulent Flow Instrumentation Pty Ltd (TFI) was mounted to a three-axis traverse system installed inside the wind

tunnel to measure streamwise approach flow velocities and turbulence intensities at 1000 Hz for 30 seconds.

Specimen 2. Platoon (three HGVs)

Three of the HGV models (as described in Specimen 1) were mounted along their centre lines on top of the suspended ground plane at an inter-vehicle gap of 300 mm (~6 m full-scale equivalent). The centre vehicle (HGV-2) is identical to the HGV model described in Specimen 1, so is the location on the turn table. Thus, surface pressures and wind loads were measured on HGV-2. The first (HGV-1) and third (HGV-3) vehicle of the platoon were identical in geometry and on-board surface pressure instrumentation but unlike HGV-2, the other two HGVs were not connected to load cells.

Experiment 1. Experiment: Yaw angle effects on surface pressures and wind loads

A repeat of Experiment 1 now conducted on Specimen 2. To mimic different crosswind condition (0° (no crosswind), 15° , 30° and 45° yaw), HGV-2 was turned by means of the turn table and HGV-1 and HGV-2 were manually re-located and mounted again to the splitter plate to remain at an inter-vehicle distance of 300 mm (reduced-scale) along their centre lines. The surface pressure sensors on all three HGV models were activated simultaneously and wind loads were measured on HGV-2. The blockage ratio for all experiments was below 3.8%.

Instrumentation

Identical to the Instrumentation described under Experiment 1 on Specimen 1. Each HGV model contained four Arduino data loggers, 14 pressure transducers and a reference pressure box in its interior.

Experiment 2. Experiment: Wake flow of HGV platoon

Wake flow measurements were performed behind HGV-1, HGV-2 and HGV-3, while platooning at 0° yaw (no crosswind). Streamwise (u), lateral (v) and vertical (w) velocity components were measured at distances (x) of 50 mm, 150 mm and 250 mm behind each HGV, corresponding to $x = 1$ m, 3 m and 5 m full-scale. At each distance, velocities were measured at a total of 99 locations, distributed over eleven lateral (y) and nine vertical (z) locations between $y = \pm 2.6$ m and $z = 0.4$ m – 5 m (with $y = 0$ at the lateral centreline of the HGVs and $z = 0$ at the floor of the splitter plate). A Series 100 Cobra probe was used to sample velocities at 1000 Hz for 30 seconds.

Instrumentation

A pitot tube located in the free stream above the suspended ground plane to measure the reference velocity (U_{ref}). The 3-components of velocity were measured using a Series 100 Cobra probe (a four-hole pressure probe) from Turbulent Flow Instrumentation Pty Ltd (TFI) mounted to a three-axis traverse system installed inside the wind tunnel.

Experiment 3. Experiment: Aerodynamic impact of overtaking manoeuvres

Specimen 2 was placed at 0° (no crosswind condition) in the wind tunnel. 44 configurations were tested to simulate the different stages of an overtaking manoeuvre, each with three repetition measurements. Because HGV-2 was connected to the load cell, the other two HGVs were disconnected from the

suspended ground plane, moved to their respective new position, and then re-attached. The overtaking manoeuvre was performed in steps of equal distance, first moving laterally, then parallel to the direction of flow until the central vehicle is the gap size ahead of the previously leading vehicle. The lateral movement is then repeated in reverse until the platoon is in-line once more.

Instrumentation

Identical to the Instrumentation described under Experiment 1 on Specimen 2.