ARTSA's Brake Test Investigation – Part 4

This is the fourth article about ARTSA'a brake test program. The tests were conducted to measure the performance of new brake technologies on the stopping distance and stability performance of a semi-trailer combination. The first article considered the brake balance performance of typical Australian and European brake set-ups. The best performance occurred with an Australian prime mover pulling an Australian trailer that had a load sensing valve (LSV) set to 65 per cent when unladen and 100 per cent when fully laden.

The second article reported on the effect of Antilock brakes (ABS) and Central Tyre Inflation (CTI) on the straight-line emergency stopping distance performance of the unladen semi-trailer combination on a dry road. The best performance occurred when the tyre pressure was set to give the optimum footprint, which occurred with tyre pressure at 290 kPa. With optimum tyre pressure, the stopping distance is about 15 per cent shorter than with high tyre pressure (650 kpa). Antilock brakes result in slightly increased stopping distances because brake modulation temporarily releases the brakes, however the change is insignificant with high tyre pressure. The ABS benefit is the improvement in directional control for all tyre pressure levels.

The third article described the cornering stability of the laden semi-trailer combination when the prime-mover and / or the trailer had an active roll-stability system (RSP). For cornering at 60 km/h the prime-mover RSP (which is a feature of the prime-mover Electronic Stability Control system) gives about a 10 km/h safety benefit whilst the trailer RSP gives about a 5 km/h safety benefit.

This article concerns Electronic Stability Control (ESC). For the prime-mover, ESC is an intelligent electronic brake control system that can activate selected prime-mover brakes and / or all the trailer brakes keep the vehicle on, or close to the desired path. To do this, the system monitors the forward velocity, the yaw velocity, the stopping deceleration, the cornering deceleration, and the driver's control inputs. All the sensors and valves communicate electronically. ESC always includes an antilock brake feature, roll-stability program (RSP) and electronic brake management; which takes account of the load on the rear suspension.

The prime-mover was a Volvo FH 540 (6x4) that is equipped with a Knorr Bremse ESC system. The semi-trailer was a MaxiTrans tri-axle trailer with BPW foundation disc brakes and Electronically Controlled Brake System (EBS). During our tests the ESC only activated all the drive-group brakes and all the trailer brakes. Therefore the prime-mover ESC has a two-level intervention. These interventions are intended to slow the vehicle. The autonomous brake action on the drive-group can be different on each side, whereas autonomous trailer braking is always the same on each side.

The trailer EBS includes a roll-stability program (RSP) and because of this it can be regarded as a 'trailer ESC' however, unlike the prime-mover ESC, it cannot activate braking on one side of the trailer only. The trailer EBS will intervene to slow the vehicle when a high risk of roll-over is determined. This action might be triggered during the double lane-change maneouver. The sensors located on the prime-mover will experience the maneouver before the sensors on the trailer do. So intervention by the prime-mover ESC will probably occur before the trailer EBS intervenes.

The performance of ESC was investigated by conducting a double-lane-change maneouver. The vehicle was driven in at successively higher starting speeds and then the same avoidance maneuover was made by the driver. The intended trajectory was a sudden diversion from one lane into the next lane and then back. The same driver achieved about the same steering input each time. The test track was kept wet to promote sliding of the wheels. A run through the course was classified as a 'pass' if the observers and the GPS record declared that the vehicle stayed within the 3.7 m lane width.

The tests were conducted for three loading conditions; which were:

- Unladen. Total weight – 23.6t.
- Half-laden with the added load above the drive-axle group. Total weight = 35.7t.
- Half-laden with the added load above the trailer tri-axle group. Total weight = 35.3 t.

The fully laden case was not tested because it induced a roll-over response, which had been previously tested (see the third article). This round of testing was intended to induce a response to sliding. It was however, noted during preliminary checks that both truck and trailer ESCs did intervene for the fully laden condition.

The results are given in the table. The following important observations were made:

- For this test vehicle, all passes had an exist speed of less than 36 km/h.
- The trailer EBS intervention (which is due to the Roll Stability Program) only occurs when the trailer is loaded.
- The prime-mover ESC intervention occurred for all the load cases.
- The prime-mover steer-axle brakes were never part of the truck ESC intervention.
- The prime-mover ESC initiated two brake pulses whereas the trailer EBS initiated one brake pulse.
- The prime-mover ESC intervention always resulted in the trailer brakes being applied by the prime-mover.
- The intervention brake pressure was always less on the prime-mover than on the trailer.
- The intervention brakes levels are relatively low compared to the levels that might have locked-up wheels. (There would be no point in an ESC intervention causing an ABS response).
- Time trace results showed that the prime-mover ESC intervention occurred before the trailer EBS intervention.
- The prime-mover ESC intervention is more effective and is more likely to occur than the trailer EBS intervention.
- The prime-mover ESC resulted in about a 5 km/h (~ + 12 per cent) improvement in safe entry speed.

The figure illustrates successful interventions by the stability control systems.

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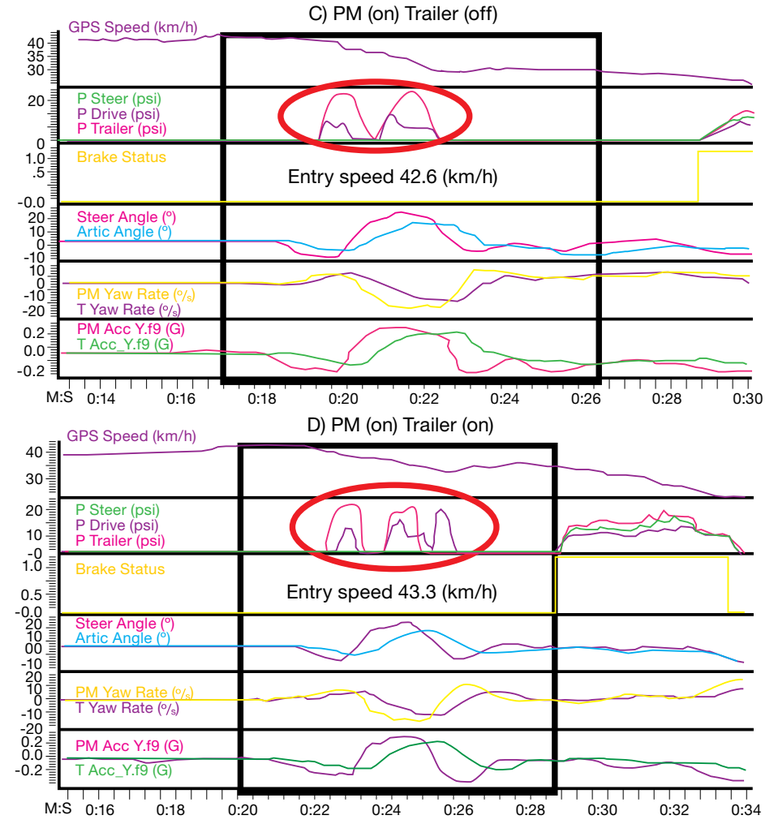

Results for maximum entry speed resulting in a pass. Brake interventions are indicated by the red ellipse.

LOAD CASE	TRUCK ESC	TRAILER ESC	ENTRY SPEED KM/H	EXIT SPEED KM/H	BRAKE INTERVENTIONS OCCURRED		
					STEER AXLE	DRIVE GROUP	TRAILER AXLE GROUP
UNLADEN TOTAL 23.6 T	ON	ON	43.8	34.5	NO	YES. TWO PULSES OF ~ 35 KPA	NO
	ON	OFF	43.8*	34.5*	NO	YES. TWO PULSES OF ~ 35 KPA	NO
	OFF	ON	38.8	35.7	NO	NO	NO
	OFF	OFF	38.8*	35.7*	NO	NO	NO
DRIVE HEAVY TOTAL 35.7 T	ON	ON	40.3	30.5	NO	YES. TWO PULSES OF ~ 35 KPA	NO
	ON	OFF	34.8	33.5	NO	YES. TWO PULSES OF ~ 35 KPA	NO
	OFF	ON	35.5	33.2	NO	NO	NO
	OFF	OFF	37.0	34.3	NO	NO	NO
TRAILER HEAVY TOTAL 35.3 T	ON	ON	43.3	35.1	NO	YES. TWO PULSES OF ~ 35 KPA	YES. THREE PULSES OF ~ 140 KPA
	ON	OFF	42.6	30.8	NO	YES. TWO PULSES OF ~ 35 KPA	YES. TWO PULSES OF ~ 140 KPA
	OFF	ON	38.4	33.2	NO	NO	YES. ONE PULSE OF ~ 140 KPA
	OFF	OFF	42.3	35.9	NO	NO	NO

* Because there was no trailer EBS intervention, these results are the same as for the row above.