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Experimental Testing of Road Space Requirements for HPMV Recovery Operations

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Waka Kotahi NZTA

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The testing programme was coordinated by Chris Carr of Carr & Haslam Ltd, who also provided the test venue, two of the test vehicles and company staff time to assist with the work. Chris also organised the mechanics to remove and refit the drive shafts to the three vehicles. This assistance was invaluable.

The tow trucks and drivers were provided by Che Bartle of ACE Heavy Haulage who also personally drove the pilot vehicle.

The third test vehicle was provided by Calvin Bonney of LW Bonney & Sons Ltd.

These contributions represent a very substantial cost saving for the project as well as facilitating smooth and efficient operations on the day. The original plan was to take a whole day to test one vehicle combination. With the assistance provided, we managed to yard test three vehicles and road test two within the same time. This was only made possible by the large amount of assistance provided.

INTRODUCTION

Vehicle recovery operations of long combination vehicles pose some significant challenges for regulators. If the vehicle being recovered is operating at its maximum allowable size and/or weight, then attaching a tow vehicle to it will generally result in the new combination exceeding the allowable size and/or weight limits.

In the New Zealand context, most of the larger vehicles on the road are "high productivity motor vehicles" (HPMVs) which operate under permit. The permitting process is based on the vehicles being able to achieve a set of performance-based standards (PBS) which have been developed to ensure that the vehicle attains an acceptable level of safety performance. Attaching a tow vehicle to an HPMV will almost degrade its performance in terms of, at least, some of the PBS and it is almost certain that the resulting combination vehicle would no longer meet all the PBS requirements.

However, the Vehicle Dimensions and Mass Rule (New Zealand Transport Agency, 2020) does include provisions for heavy vehicle recovery operations to exceed size and weight limits. Section 3.14(11) addresses the applicability of the size and weight limits to heavy vehicle recovery operations and states:

> *3.14(11)* *A heavy vehicle recovery service vehicle may tow a heavy motor vehicle that has become disabled while on a roadway, and any attached trailers, to the nearest safe area, taking account of traffic volume, vehicle load, and the ability to undertake repair safely at the roadside, off the roadway (that is accessible without contravening any bridge weight limit including posted limits) and does not have to—*
>
> *(a) comply with the dimension requirements in Schedule 2; or*
>
> *(b) comply with the mass ratio of towed and towing vehicles in 4.5; or*
>
> *(c) be operated under an overdimension permit*

There have been differences of interpretation of these provisions between vehicle recovery operators and the police. The NZTA are therefore undertaking a review of heavy vehicle recovery operations of long combination vehicles. As part of this review, The NZTA have engaged TERNZ to measure some of the key performance characteristics of a heavy-duty recovery vehicle towing an HPMV.

This report describes the testing that was undertaken and presents the results of these tests.

TESTING PROGRAMME

The testing was undertaken on Friday, September 11th, 2020 at the premises of Carr & Haslam in Mt Richmond Drive, Otahuhu and then on roads between Penrose and Manukau in Auckland. The tow truck vehicles and drivers were provided by Ace Towing Limited and the towed vehicles were supplied by Carr & Haslam Ltd and by L.W. Bonney & Sons Ltd.

The longest vehicles that operate in large numbers on the New Zealand road network are 23m HPMVs of which there are more than 10,000 vehicles. There are three main vehicle configurations used in HPMV operations:

- 23m truck and full trailer
- 23m B-train
- 23m truck and simple trailer (typically for car transport)

For the testing, one example of each configuration was used. The three vehicles used are shown below. Figure 1 show a 23m truck and trailer curtainsider unit used for linehaul operations which can operate at up to 57.8 tonnes gross combination weight on its approved route. It also meets the requirements for 50MAX operations and thus is typical of most of the HPMV 23m truck and trailer combinations on the road. Figure 2 shows 23m liquid tanker B-train. This also meets the 50Max requirements and thus is typical of most of the HPMV B-trains on the road. The final vehicle shown in Figure 3 is a 23m truck and simple trailer car transporter. These vehicles are limited to a gross combination weight of 40 tonnes. The additional length enables them to carry more cars. This vehicle configuration is also used for other low density loads such as empty container transport.

Figure 1. Carr & Haslam 23m linehaul truck and trailer combination.

Figure 2. LW Bonney & Sons 23m liquid tanker B-train.

Figure 3. 23m Carr & Haslam truck and simple trailer car transporter.

The towing vehicle used was a Kenworth 8x4 truck fitted with specialist hydraulic towing and lifting equipment as shown in Figure 4. The tow coupling can be adjusted for both height and length. At the end of the tow beam, there is a T-bar which pivots on the tow beam about a vertical axis. This T-bar is connected to the towed vehicle. In the case of the truck and trailer and the B-train, the trucks were designed to be fitted with adapter hooks that the T-bar could connect to as shown in Figure 5. In the case of the car carrier vehicle, the T-bar was connected to the front axle of the towed vehicle as shown in Figure 6. With the tow truck connected, the truck and trailer combination with tow truck was 33.7m long, the car carrier with the tow truck was 33.3m long and the B-train and tow truck was 33.0m long.

Figure 4. ACE heavy vehicle recovery truck.

Figure 5. Connecting the tow truck to the 23m truck and trailer.

Figure 6. Towing connection to the front axle of the towed vehicle.

Heavy vehicles should not be towed above crawl speed for any distance without first removing the driveshaft. The reason for this is that, if the driveshaft is connected, it will cause the output shaft on the gearbox to turn but, because the engine is not running, the gearbox bearings will not be lubricated which will result in damage to these bearings. Thus, all three vehicles had their driveshafts removed before testing commenced.

The New Zealand PBS system uses two low speed turning manoeuvres. The first is a 12.5m outside radius 90° kerb-to-kerb turn and the second is a 25m outside radius 360° wall-to-wall turn. The performance measures that are evaluated using the first manoeuvre are low speed swept width, frontal swing, tail swing and steer tyre friction utilisation. In the second manoeuvre, we evaluate low speed steady state swept width.

Figure 7. Aerial view of towed B-train executing 12.5m radius 90° turn.

For the yard-based testing we marked out guide lines for these two manoeuvres using landscapers spray chalk. Figure 7 shows the towed B-train executing the first manoeuvre. The guide lines for the 25m radius turn can be seen on the inside of this turn.

For the yard testing the combination vehicles were fitted with two pressurised water sprayer units. One of these was fitted to the right front corner of the tow truck and the other was fitted to the rearmost vehicle on the left-hand side in line with the rear axle. The sprayers were activated at the start of each manoeuvre and traced out the innermost and outermost paths of the vehicle. In addition, a wand was attached to the rightmost corner of the vehicle and the maximum tail swing was marked out manually using chalk by the author walking behind the truck.

Each of the three towed vehicles was driven at crawl speed around the 90° turn at least three times and measurements were taken of swept width, frontal swing and tail swing. Following the is the vehicle was driven at crawl speed around the 25m radius 360° turn and a number of measurements of the swept width were taken in the region beyond 180° of turn.

Following the yard testing, the sprayer units were removed from the vehicles and the B-train was configured for on-road towing. This required the fitting of hazard lights, oversize vehicle signage and connecting the lights and the braking system to the tow truck. The towed combination was accompanied by a pilot vehicle and observed with a video camera from a following vehicle. The route was selected by ACE towing and was designed to show the combination's turning performance on tight corners on public roads as shown in Figure 8. Following the test of the B-train, the tow truck was coupled to the 23m truck and trailer combination and the on-road test was repeated. For the truck and trailer test, the route was modified to avoid some of the traffic congestion experienced with the B-train test. The truck and trailer route is shown in Figure 9.

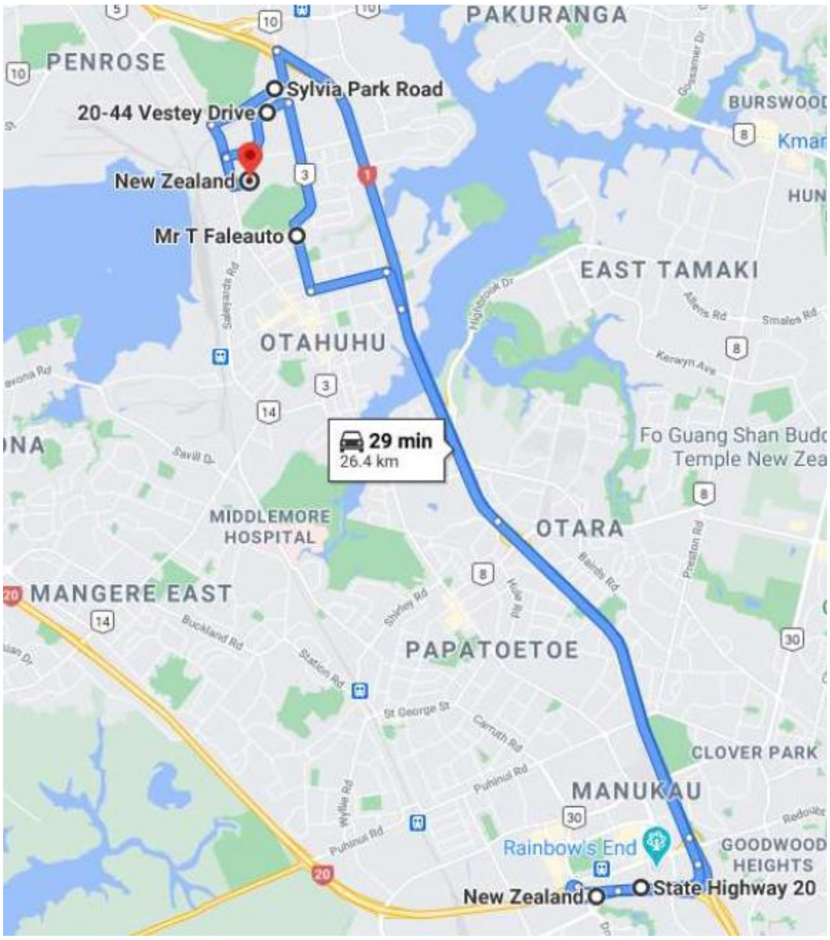

Figure 8. Route taken by towed 23m B-train during on-road test.

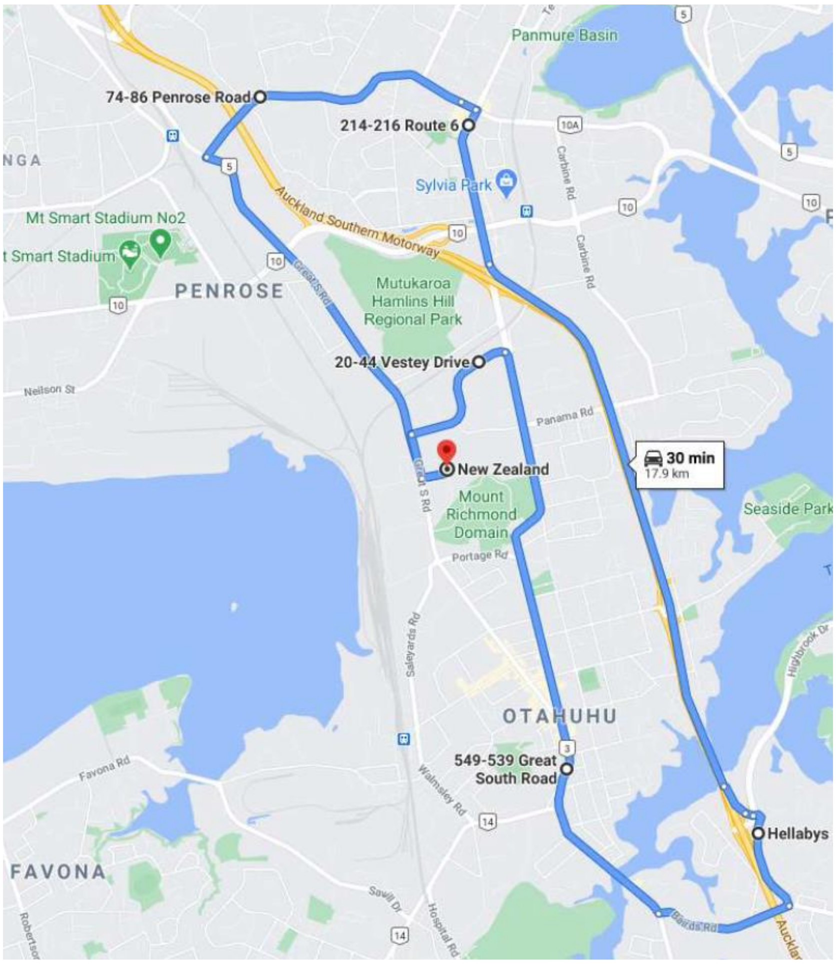

Figure 9. Route taken by towed 23m truck and trailer during on-road test.

RESULTS

The average values for the performance measures evaluated in the yard tests are shown in Table 1. The acceptability levels shown in the table are the values used by the new New Zealand PBS system for assessing whether HPMVs can achieve general access to the network subject to applicable weight restrictions. Most over-dimension vehicles would typically not achieve all these performance requirements. The New Zealand PBS system is still in the process of being implemented and thus the three HPMV vehicles being tested also do not necessarily achieve all the PBS requirements. The low speed turning performance requirements of the new PBS system are more demanding than the requirements that were in place when these vehicles were permitted.

Table 1. Results of low speed turning performance measurements of the three towed HPMV combinations.

Performance Measure	Acceptability Level	Average values for towed vehicles		
		Truck and trailer	Car carrier	B-train
Low Speed Swept Width (m)	Less than 6.95	7.79	7.46	8.15
Tail Swing (m)	Less than 0.3	0.17	0.34	0.06
Frontal Swing (m)	Less than 0.75	0.54	0.55	0.55
Steady State Low Speed Swept Width (m)	Less than 5.20	5.56	5.40	6.08

The frontal swing measure depends primarily on the front overhang and wheelbase of the towing vehicle. Therefore, there is virtually no difference between the three combinations. The frontal swing values are well inside the acceptability limit.

The tail swing depends on the rear overhang of the rearmost trailer as well as the wheelbases and coupling positions of the vehicle units ahead of it. For the truck and trailer and the B-train, the tail swing is well inside the acceptability limit. The tail swing of the car carrier is just over (by 40mm) the acceptability limit.

All three combinations exceed both the swept width requirements. The B-train combination generates the largest swept width, followed by the truck and trailer combination with the car carrier combination producing the least.

The first low speed swept width measure relates to the 90° turn at 12.5m outside radius which characterises the road width required for a turn at an intersection. The three vehicle combinations exceed the acceptable level by 0.84m, 0.51m and 1.2m, respectively. The effect of this increased swept width was observed in the road tests.

The Australian PBS system uses the same low speed swept path measure but with different acceptability levels for different road classes. At level 1, which is general access, their acceptability level is less than 7.4m, while at level 2, which corresponds to their B-double routes, their acceptability level is less than 8.7m. The B-double routes are used for 26m B-train operations as well as suitable PBS vehicles. Thus, the towed combinations tested perform better than Australian 26m B-trains.

The steady state low speed swept width quantifies the level of inboard offtracking on lower speed highway curves. However, the net offtracking on highway curves is the combination of the inboard offtracking due to the vehicle geometry and the outboard offtracking due to the kinematics (the tyre slip angles required to counter the centrifugal forces).

The on-road tests did show that the towed vehicle combinations required additional road width on tight turns at intersections. This was typically addressed by occupying 1.5 to 2 lanes at the intersection approach which did not create any safety risk because the pilot vehicle was used to prevent following vehicles from encroaching on the vehicle. Figure 10 and Figure 11 show two examples of these tight turns.

In both cases, the towed combination uses additional road space at the entry to the turn but stays within its lane at the exit of the turn. The pilot vehicle follows the combination through the turns and prevents other vehicles from attempting to pass the towed combination on the right.

Figure 10. Towed B-train turning right from Great South Rd into Sylvia Park Rd.

Figure 11. Turning right onto the southbound motorway on-ramp on the Mt Wellington Highway.

When there is a little more room available the towed combination can complete intersection turns while remaining within it is lane. Figure 11 and Figure 12 show two examples of these turns.

Figure 12. Turning right from Great South Rd into Penrose Rd.

Figure 13. Turning right from Princes St, Otahuhu onto Atkinson Ave northbound.

The tracking of the combinations through curves was generally quite good. Figure 14 shows the two vehicle combinations on the same 35km/h curve on the Mt Wellington Highway. Although they use the full lane width available, they do not encroach on the oncoming traffic lane. Figure 15 and Figure 16 show two higher speed curves and the vehicle tracking on these is excellent.

Figure 14. Northbound in the 35 km/h advisory speed curve at the Otahuhu end of the Mt Wellington Highway.

Figure 15. 65km/h curve connecting SH1 to SH20.

Figure 16. 45km/h curve on Penrose Rd.

CONCLUSIONS

Two sets of tests were undertaken on a heavy vehicle recovery vehicle towing 23m HPMVs. The first set of tests was undertaken in Carr & Haslam's yard in Otahuhu. Three 23m HPMVs vehicles, a truck and full trailer, a truck and simple trailer (car carrier) and a B-train were tested used the standard PBS low speed turning manoeuvres. With the tow connected, the overall lengths of these three combinations were 33.7m, 33.3m and 33.0m, respectively.

Not surprisingly the low speed swept width values of these three combinations were greater than the maximum values allowed for general access HPMV vehicles. The greatest swept width was generated by the B-train combination followed by the truck and full trailer with the truck and simple trailer producing the least swept of the three. The truck and simple trailer did, however, slightly exceed the tail swing limit while the other two combinations were well within it. All three combinations achieved the frontal swing limit.

The worst-case vehicle combination, the towed B-train, exceeded the two low speed swept width limits by 17%. Interestingly, all three vehicle combinations would meet the low speed swept width limits for level 2 vehicles in Australia. Level 2 is based on their 26m B-trains.

Following the yard tests, the two worst-performing combinations, the B-train and the truck and full trailer, were taken on a road circuit and video-recorded from a following vehicle. They were also accompanied by a pilot vehicle. The test circuits were chosen to include some tight turns and difficult intersections in order investigate the vehicle combinations' performance in worst-case conditions. This is counter to normal practice where the recovery vehicle operator would try to select a route that, wherever possible, avoided difficult turns and intersections.

As expected, the towed combinations did require additional road space for some, though not all, intersection turns. This was easily managed by the pilot vehicle controlling the following traffic to avoid conflicts. The towed combinations were limited to a maximum speed of 70 km/h. The tracking of the combinations at speed was excellent. On the 35 km/h curves, they occupied the full lane width but did not encroach on oncoming traffic. On higher speed curves, the vehicle combinations tracked comfortably within their lane with a good safety margin.