



New PBS Requirements:  
Replacement Pro-forma  
Designs for 23m Truck and  
Trailer Combinations

Version 4

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Transport Engineering Research New Zealand Limited (TERNZ) is a research organisation providing high quality independent research services to the transport industry.

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## INTRODUCTION

In association with the 2016 review of the Vehicle Dimensions and Mass (VDAM) Rule, the NZTA also initiated a project to formalise the performance-based standards (PBS) for use in New Zealand. The current pro-forma designs were developed using a set of performance measures largely based on those originally developed in the Road Transport Association of Canada (RTAC) study in the 1980s and the Australian PBS system which came into force in 2008.

The pass/fail criteria for low speed turning performance were based on the performance of the worst case standard legal vehicle; the quad-axle semi-trailer combination. Observations undertaken of some limit-case HPMVs in operation found that, at some pinch point curves on the network, the vehicles occupied the full lane width. Thus, if two such vehicles were to meet at one of these curves there would be little safety margin. The NZTA therefore required that the low speed turning performance requirements in the proposed New Zealand PBS system be more demanding so that the limit-case vehicles use less road width at the pinch-point curves. The new PBS system has now been developed. Because the low speed turning performance requirements are more demanding than those used for the current pro-forma designs, all the current pro-forma designs will need to be reviewed and modified. This provides an opportunity to rationalise these pro-forma designs into a more coherent set.

This report presents a review of the three main 23m truck and trailer pro-forma designs and develops two new pro-forma truck and trailer designs to replace them. Although the NZTA is aiming for a degree of standardisation in the heavy vehicle fleet and thus will only permit one-off HPMV designs for special-purpose applications, they are not imposing any limit on the number of pro-forma designs. So, while the two new pro-forma truck and trailer designs are intended to satisfy the requirements for most transport activities that use truck and trailer combinations, they do not need to cover every possible application. It will be possible to create additional pro-forma designs if they are needed.

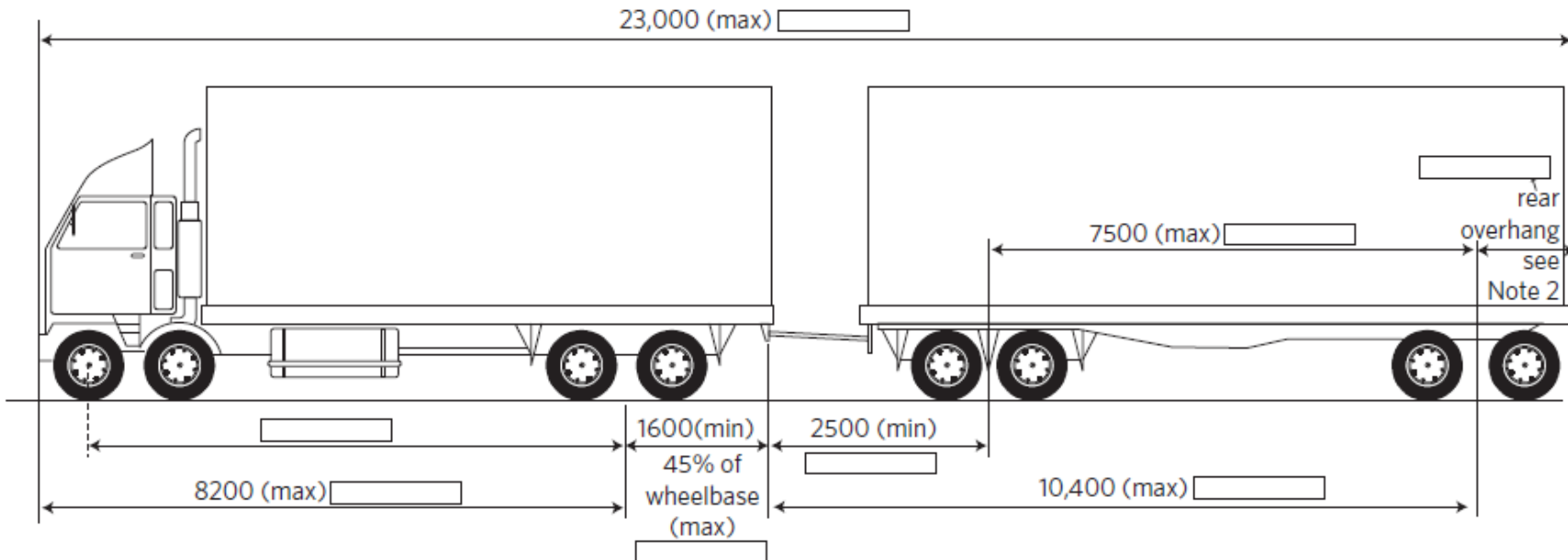
## THE CURRENT PRO-FORMA DESIGNS

The three main 23m truck and trailer pro-forma designs currently in use are shown in Figure 1-Figure 3. In addition, there is a 23m truck and trailer design for log transport which has been updated with a new design that meets the new PBS requirements. The original log truck design was virtually identical to the standard 23m truck and full trailer design shown in Figure 1, with the only real difference being additional provisions to exceed the front overhang limit on the trailer and operate with a reduced inter-vehicle spacing. The updated 23m log truck and full trailer design is more explicitly configured to match current practice in the industry.

There is also a proposed new pro-forma 9-axle truck and trailer design with a caster steer axle in the last axle position. This design was motivated by the dairy industry and is designed to have a superior level of low speed turning performance, i.e. significantly better than the minimum acceptable level in the PBS system. This is needed by dairy tankers for accessing farm tanker tracks from relatively narrow country roads and for turning around at milking sheds. This design could potentially also be useful for stock trucks, which have similar access requirements. The fitting of a caster steer axle adds to the capital cost of the vehicle and increases the tare weight which reduces payload capacity. Furthermore, the caster steer axle needs to be locked at higher speeds and thus there are increased maintenance costs associated with the steering mechanism and the locking mechanism. For these reasons, this design is not ideal for most freight operations where the additional manoeuvrability is not required.

Two of the three main current pro-forma designs, (the long trailer design in Figure 2 and the long drawbar design in Figure 3) are very similar to each other. Both designs use the same truck length. The long trailer design has a larger minimum coupling offset which enables it to have a larger maximum trailer wheelbase than the long drawbar design. In this analysis we are proposing a single design to replace both these existing designs which we have called the "23m Shorter Truck and Full Trailer". Note that the NZTA are comfortable with having a greater number of pro-forma designs and thus, if this design does not meet the requirements of all freight sectors, then it will be possible to create additional pro-forma designs that address the shortcomings of this design.

### 23m Truck and full-trailer

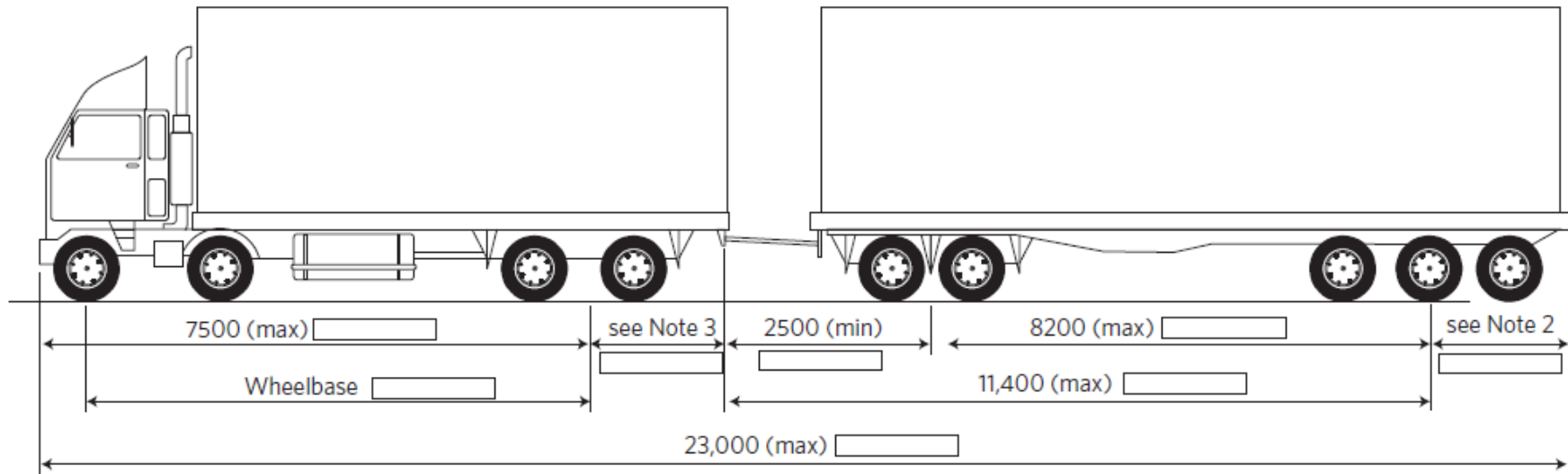


Please fill in the boxes with your vehicle's dimensions

**Note 1** Axle groups can be replaced with alternate groups at the same axis points

**Note 2** Max. is lesser of 4300 or 50% of wheelbase

Figure 1. Standard 23m truck and full trailer pro-forma design.

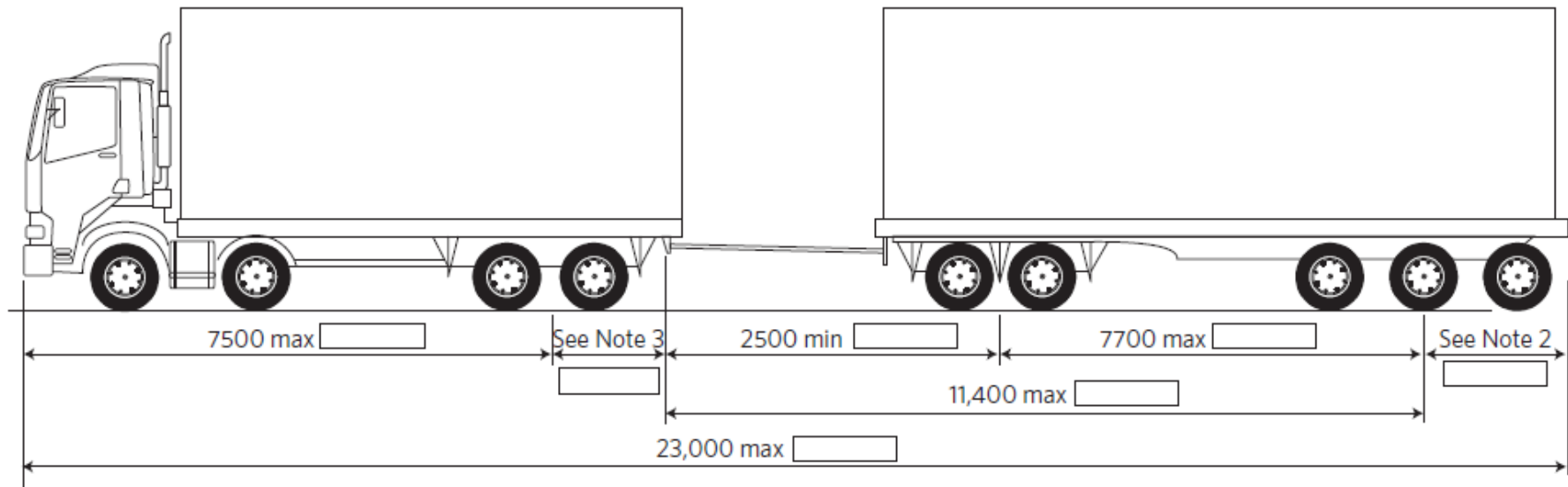


**Note 1** Axle groups can be replaced with alternate groups at the same axis points

**Note 2** Max. is lesser of 4300 or 50% of wheelbase

**Note 3** Minimum of 2000mm or maximum of 45% of wheelbase

Figure 2. 23m truck and long trailer pro-forma design.



**Note 1** Axle groups can be replaced with alternate groups at the same axis points.

**Note 2** Maximum is lesser of 4300 or 50% of the wheelbase.

**Note 3** Minimum of 1750mm or maximum of 45% of the wheelbase.

Figure 3. 23m truck and trailer long drawbar pro-forma design.

## THE NEW PRO-FORMA DESIGNS

The truck dimensions in the existing pro-forma designs were based on the dimensions of vehicles currently used in New Zealand. As almost all these vehicles are imported fully built up, changing the truck dimension limits is not desirable. Although modifications to these dimensions are possible, they are costly, and the result is often structurally inferior to the original.

One area where it is possible to make a change is in how the forward length is defined. The existing pro-forma designs were developed assuming that the front of the truck is 2400mm wide, completely flat with square corners. In practice, all truck front bumpers have rounded corners, and, in many cases, they are curved rather than flat. This often means that the vehicle can still achieve the low speed turning performance requirements when the truck's forward length is a little greater than the nominal maximum value. In the two new pro-forma B-train designs, we have introduced the concept of a nominal forward distance that allows the actual forward distance to be greater when the front bumper is curved. We will apply the same methodology to the trucks for these two designs. Note, however, that although this approach allows slightly longer trucks to be used, it does not provide for an increase in overall combination length.

Because the low speed turning performance requirements of the new PBS system are more demanding than those used to develop the current pro-forma designs the trailers will need to have shorter wheelbases. This does not necessarily mean any loss of payload space. A shorter wheelbase can be offset with a larger rear overhang.

We can regard a full trailer as effectively being two vehicle units, a dolly and a semi-trailer, that are coupled with a ball-race turntable. In the existing pro-forma designs, the length of the full trailer is controlled by setting an upper limit for the combined wheelbase (truck coupling point to the rear axis) and for the trailer wheelbase (centre of turntable to the rear axis). Thus, if a longer drawbar is required, then a shorter trailer wheelbase must be used and vice-versa. There is some flexibility in setting these limits. The best low speed turning performance is achieved when the wheelbases of the two vehicle units are equal, but this gives the vehicle designer little flexibility and the resulting configuration is not one that is currently widely used. Consequently, we have adjusted the wheelbase limits of the current pro-forma designs in a way that we think will suit most operators. As noted previously, the NZTA is happy to have additional pro-forma designs and so, if there are transport sectors that need a different vehicle design configuration, it will be possible to address this with a new pro-forma design.

The current standard 23m truck and full-trailer pro-forma design has a maximum combined trailer wheelbase of 10,400mm and a maximum trailer wheelbase of 7,500mm. For this design we maintained the combined trailer wheelbase limit and reduced the trailer wheelbase limit. By trial-and-error, the maximum wheelbase value that could achieve the low speed turning performance requirements was 7,100mm.

We initially proposed a 23m shorter truck and full trailer pro-forma design that was intended to be a replacement for both the current 23m truck and long trailer and the 23m truck and long drawbar trailer designs. Both these current designs have a truck with a maximum forward length of 7,500mm but have different minimum coupling offsets. The long drawbar design has a minimum coupling offset of 1,750mm while the long trailer design has a minimum coupling offset of 2,000mm. For the proposed new design, we have set the minimum coupling offset at 1,750mm. Both current designs have a maximum combined wheelbase of 11,400mm but the long trailer design has a maximum trailer wheelbase of 8,200mm while the long drawbar design has a maximum trailer wheelbase of 7,700mm. For the new pro-forma design, we proposed a maximum trailer wheelbase between these two limits and consequently had to have a reduced combined wheelbase limit. By trial-and-error we arrived at a maximum trailer wheelbase of 8,000mm with a maximum combined wheelbase of 10,800mm.

The results of applying the New Zealand PBS system to models of the limit cases of these two proposed new pro-forma designs are shown in Table 1. For these vehicles, the steady state low speed swept width measure is at critical value. The low speed swept width is approaching the critical value but is just below it. The payload height has been selected to produce a Static Rollover Threshold (SRT) value that is close to

the worst case, which will produce the worst-case performance for the high-speed performance measures. All the other performances are comfortably within the allowable levels.

**Table 1. Performance assessment of the two proposed new pro-forma designs.**

Performance Measure	Acceptability Level	Standard 23m truck and trailer design	23m shorter truck and trailer design
Low Speed Swept Width (m)	Less than 6.95	6.91	6.87
Tail Swing (m) - Load	Less than 0.3	0.06	0.08
Frontal Swing (m)	Less than 0.75	0.55	0.51
Steer-Tyre Friction Demand	Less than 0.50	0.37	0.34
Steady State Low Speed Swept Width (m)	Less than 5.20	5.20	5.19
High Speed Offtracking at 0.2g (m)	Less than 0.46	0.40	0.38
High Speed Offtracking at 0.25g (m)	Less than 0.68	0.56	0.55
Static Rollover Threshold (g)	Greater than 0.35	0.36	0.35
Dynamic Load Transfer Ratio	Less than 0.6 (0.7)	0.43	0.41
Rearward Amplification	Less than 2	1.62	1.52
High Speed Transient Offtracking (m)	Less than 0.6	0.31	0.29
Yaw Damping Ratio (%)	Greater than 15	32	38

The limit cases of the dimensions for two pro-forma designs will generate the worst-case low speed turning performance. Choosing values for these critical dimensions that are within these limits will give improved low speed turning performance but can potentially worsen the high-speed dynamic performance. Therefore, we need to investigate these dimensional variations to ensure that the designs remain within the allowable limits for all the performance measures. If they do not, it will be necessary to impose additional constraints on the appropriate dimensions.

For worst-case low speed turning performance the coupling offset on the trucks was set at the minimum allowable levels. These were 1600mm for the standard vehicle and 1750mm for the shorter truck vehicle. The maximum allowable coupling offset is 45% of the wheelbase which aligns with the allowable limit for standard legal vehicles in the Vehicle Dimensions and Mass (VDAM) rule. The truck models that were used in this analysis had a front overhang of 1,000mm measured from the first axle. Thus, for the standard 23m truck and full trailer design the maximum truck wheelbase was 7,200mm and hence the maximum coupling offset was 3,240mm. For the 23m shorter truck and trailer design the maximum truck wheelbase was 6,500mm and hence the maximum coupling offset was 2,925mm. The two vehicle designs were modelled with these maximum coupling offsets. For both models, the trailer wheelbases are kept at the maximum allowable levels. For the shorter truck vehicle, the combined trailer wheelbase was also set at the maximum allowable value. For the standard 23m vehicle, setting the maximum combined trailer wheelbase at the maximum allowable value would have resulted in the overall length of the vehicle exceeding 23m and so the drawbar was shortened such that the trailer rear overhang behind the rearmost axle was 700mm. The results of modelling these two vehicles are shown in Table 2.

The impact of these changes is most striking on the standard 23m vehicle. There is significant improvement in low speed turning performance at the expense of some aspects of high-speed performance, in particular, rearward amplification and high speed off-tracking. For the 23m shorter truck vehicle, the effects are similar but of lesser magnitude. In both cases, the vehicles achieve all the required performance standards. Thus, it appears that the allowable range of coupling offset dimensions is acceptable. Note that it is possible for the front overhang to be a little less than the value used in the models which could allow a



slightly larger truck wheelbase and hence coupling offset but none of the results for any of the performance standards are close to critical and so these vehicles would still have acceptable performance.

**Table 2. Performance assessment of the two proposed new pro-forma designs with maximum coupling offset.**

Performance Measure	Acceptability Level	Standard 23m truck and trailer design	23m shorter truck and trailer design
Low Speed Swept Width (m)	Less than 6.95	6.42	6.61
Tail Swing (m) - Load	Less than 0.3	0.17	0.11
Frontal Swing (m)	Less than 0.75	0.55	0.50
Steer-Tyre Friction Demand	Less than 0.50	0.37	0.34
Steady State Low Speed Swept Width (m)	Less than 5.20	4.83	5.00
High Speed Offtracking at 0.2g (m)	Less than 0.46	0.44	0.43
High Speed Offtracking at 0.25g (m)	Less than 0.68	0.62	0.61
Static Rollover Threshold (g)	Greater than 0.35	0.36	0.35
Dynamic Load Transfer Ratio	Less than 0.6 (0.7)	0.43	0.41
Rearward Amplification	Less than 2	1.82	1.69
High Speed Transient Offtracking (m)	Less than 0.6	0.33	0.28
Yaw Damping Ratio (%)	Greater than 15	35	39

Another dimensional variation that is possible is the trailer wheelbases, which can be significantly shorter than the maximum allowable dimension. To evaluate the effect of shorter wheelbases we have modelled the vehicles with the minimum coupling offsets and the trailer wheelbases equal to half the combined trailer wheelbase at its maximum value. The results of this analysis are shown in Table 3.

As with the previous case, reducing the trailer wheelbase improves the low speed turning performance but the degrades the high-speed performance. The effect is greater on the shorter truck design. Both vehicle designs still achieve all the performance requirements, but the rearward amplification and the load transfer ratio are approaching the acceptability limit. In the analysis we limited the trailer wheelbase value to a minimum of half the combined trailer wheelbase which effectively means that the trailer wheelbase could not be less than the drawbar length. In principle, there is no reason why the trailer wheelbase could not be shorter still although as the wheelbase decreases, the reduced axle spread means that the allowable maximum gross weight for the trailer also reduces.

Within the design templates, there is also no reason why a vehicle designer could not create a vehicle with both a larger coupling offset and a short trailer wheelbase and so we modelled the cases where the coupling offset was at the maximum allowable value and the trailer wheelbases were at half the maximum combined trailer wheelbase. The results for this case are shown in Table 4. Again, for the standard 23m vehicle, it was necessary to reduce the combined trailer wheelbase so that the 23m overall length limit was not exceeded. This reduction was achieved by shortening the drawbar. A minimum rear overhang of 700mm behind the rearmost trailer axle was maintained. As expected, applying both these variations simultaneously further improves the low speed turning performance at the expense of high-speed performance. For both designs, several of the high-speed performance measures are now at or near to the acceptability limits, namely, both high-speed offtracking measures, dynamic load transfer ratio and rearward amplification. With the 23m standard design, the rearward amplification is fractionally over the acceptable limit. Increasing the trailer wheelbase from 5,200mm to 5,400mm resolves this issue.

**Table 3. Performance assessment of the two proposed new pro-forma designs with shorter trailer wheelbase.**

Performance Measure	Acceptability Level	Standard 23m truck and trailer design	23m shorter truck and trailer design
Low Speed Swept Width (m)	Less than 6.95	6.72	6.55
Tail Swing (m) - Load	Less than 0.3	0.05	0.08
Frontal Swing (m)	Less than 0.75	0.55	0.51
Steer-Tyre Friction Demand	Less than 0.50	0.37	0.34
Steady State Low Speed Swept Width (m)	Less than 5.20	5.00	4.86
High Speed Offtracking at 0.2g (m)	Less than 0.46	0.41	0.41
High Speed Offtracking at 0.25g (m)	Less than 0.68	0.58	0.58
Static Rollover Threshold (g)	Greater than 0.35	0.36	0.35
Dynamic Load Transfer Ratio	Less than 0.6 (0.7)	0.53	0.49
Rearward Amplification	Less than 2	1.84	1.83
High Speed Transient Offtracking (m)	Less than 0.6	0.36	0.36
Yaw Damping Ratio (%)	Greater than 15	22	23

**Table 4. Performance assessment of the two proposed new pro-forma designs with maximum coupling offset and shorter trailer wheelbase.**

Performance Measure	Acceptability Level	Standard 23m truck and trailer design	23m shorter truck and trailer design
Low Speed Swept Width (m)	Less than 6.95	6.22	6.30
Tail Swing (m) - Load	Less than 0.3	0.18	0.10
Frontal Swing (m)	Less than 0.75	0.55	0.51
Steer-Tyre Friction Demand	Less than 0.50	0.37	0.34
Steady State Low Speed Swept Width (m)	Less than 5.20	4.64	4.66
High Speed Offtracking at 0.2g (m)	Less than 0.46	0.46	0.46
High Speed Offtracking at 0.25g (m)	Less than 0.68	0.65	0.64
Static Rollover Threshold (g)	Greater than 0.35	0.36	0.35
Dynamic Load Transfer Ratio	Less than 0.6 (0.7)	0.58	0.59
Rearward Amplification	Less than 2	2.02	1.92
High Speed Transient Offtracking (m)	Less than 0.6	0.42	0.43
Yaw Damping Ratio (%)	Greater than 15	26	27

The vehicles have been modelled at HPMV weights. Thus, the gross combination weight used was 58 tonnes or 59 tonnes depending on the first-to-last axle spacing. The height of the centre of gravity of the payload was adjusted to give an SRT value close to the 0.35g minimum allowed. This should generate the

worst-case performance for the high-speed performance measures. In practice, many vehicles will operate with higher SRT values and will have superior performance for some of the high-speed standards.

Based on these results the two pro-forma design templates were created and a draft report outlining the analysis was circulated to the industry through the Truck Trailer Manufacturers’ Federation (TTMF). The standard 23m truck and trailer pro-forma design was generally considered acceptable and little feedback was received on this design. However, the 23m shorter truck and trailer design was more contentious. Essentially the proposed design had attempted to encompass two different types of vehicle – the long wheelbase trailer with a short drawbar and the short wheelbase trailer with a long drawbar – within the same template.

This approach had introduced some compromises that were not acceptable to stakeholders. With the range of coupling offset values that were permitted, it was necessary to restrict the maximum total trailer forward length and the minimum trailer wheelbase to values that the industry felt were too restrictive. The NZTA participated in this stakeholder consultation and agreed that they would consider a pro-forma design where some of the critical dimensions were related to each other in a tabular form. Thus, for example, there could be a set of minimum coupling offset values each with an associated maximum trailer wheelbase value. To keep these tables as simple as possible, it was decided to separate the long trailer design from the long drawbar design.

With the current designs, the maximum total trailer forward length is 11,400mm. The initial proposal was to reduce this to 10,800mm but the industry felt this was too restrictive and so for the long trailer design we have set the limit to 11,200mm while for the long drawbar design we have set it to 11,400mm. Note that, to achieve the same low speed turning performance for a given coupling offset, a longer total trailer forward length requires a shorter trailer wheelbase. Increasing the coupling offset, increases the maximum allowable trailer wheelbase. Thus, by trial and error, we determined the maximum allowable trailer wheelbase values for a set of minimum coupling offset values shown in Table 5.

**Table 5. Maximum trailer wheelbase limits for minimum coupling offset values.**

Minimum Coupling Offset (mm)	Maximum Trailer Wheelbase (m)
1600	7.70
1800	7.78
2000	7.86
2200	7.94

As noted previously, having a larger coupling offset and a shorter trailer wheelbase will worsen the high speed dynamic performance of the vehicle and thus we need to determine the shortest allowable trailer wheelbase that will achieve satisfactory high-speed performance when the coupling offset is at the maximum allowable level. This value was 5.4m. Table 6 shows the results of a performance assessment of two limit cases of this family of pro-forma designs. The first uses the minimum coupling offset (CO) with the maximum trailer with the corresponding maximum trailer wheelbase (WB). The second uses the maximum CO (45% of the truck wheelbase) with the minimum trailer wheelbase. Thus, the first case should represent a worst-case low speed turning performance while the second case should represent a worst-case high-speed performance. A review of the results in Table 6 shows that this is indeed the case. The Min CO-Max WB vehicle is 20mm below the maximum allowable Low Speed Swept Width and right on the limit for the Steady State Low Speed Swept Width but comfortably achieves all the high-speed performance standards. On the other hand, the Max CO-Min WB vehicle comfortably achieves the low speed turning performance standards but is on the limit for High-Speed Offtracking at 0.2g and for Dynamic Load Transfer Ratio. Thus, this family of pro-forma designs achieves the performance standards and should meet the industry requirements for a 23m truck and long trailer configuration.

**Table 6. Performance assessment of two limit cases for 23m truck and long trailer pro-forma design.**

Performance Measure	Acceptability Level	Min CO	Max CO
		Max WB	Min WB
Low Speed Swept Width (m)	Less than 6.95	6.93	6.30
Tail Swing (m) - Load	Less than 0.3	0.05	0.10
Frontal Swing (m)	Less than 0.75	0.51	0.51
Steer-Tyre Friction Demand	Less than 0.50	0.34	0.34
Steady State Low Speed Swept Width (m)	Less than 5.20	5.20	4.66
High Speed Offtracking at 0.2g (m)	Less than 0.46	0.40	0.46
High Speed Offtracking at 0.25g (m)	Less than 0.68	0.57	0.64
Static Rollover Threshold (g)	Greater than 0.35	0.35	0.35
Dynamic Load Transfer Ratio	Less than 0.6 (0.7)	0.43	0.60
Rearward Amplification	Less than 2	1.56	1.94
High Speed Transient Offtracking (m)	Less than 0.6	0.32	0.44
Yaw Damping Ratio (%)	Greater than 15	35	27

Although it is possible to incorporate the 23m truck and long drawbar trailer configuration within this family of pro-forma designs, this would increase the complexity of Table 5 because we would need to specify minimum and maximum coupling offsets and minimum and maximum trailer wheelbases for each row of the table. Furthermore, the stakeholder feedback supported have a maximum total trailer forward length of 11,400mm rather than 11,200mm for this vehicle configuration. Making this change reduces the allowable maximum trailer wheelbase but this is not a concern for this configuration.

For this total trailer forward length, with a minimum coupling offset of 1600mm, the maximum trailer wheelbase at which the low speed turning performance standards could be achieved was 7500mm. For high-speed performance, with a maximum coupling offset of 2200mm, the minimum trailer wheelbase that could be achieved was 4700mm. Although it would be possible to achieve a shorter minimum trailer wheelbase by reducing the maximum coupling offset, there is little point to doing this because it reduces the trailer weight capacity and hence the weight capacity of the combination.

Table 7 shows the detailed results for the performance assessment of these two limit cases of this design. As with the long trailer design, the case with the maximum trailer wheelbase reflects the limits of low speed turning performance while the minimum trailer wheelbase reflects the limits of high-speed turning performance.

For all the truck and trailer combinations analysed the HPMV gross combination weight limit is determined by the first-to-last axle spacing. With B-trains using 3-axle tractors, the second-to-last axle spacing is often the limiting factor but with a twin-steer configuration this is not the case.

As there is an overall length limit of 23m, the maximum value of the first-to-last axle spacing is determined by the front overhang forward of the first axle and the rear overhang rearward of the last axle. For current trucks, the front overhang varies from about 700mm up to just over 1500mm. The rear overhang needs to accommodate a rear bumper behind the tyres, which provides rear underrun protection. Typically, a minimum rear overhang of about 700mm is required. If we consider a truck with the maximum front overhang, the total of the overhangs is 2.2m. This means that the maximum achievable first-to-last axle spacing is 20.8m which allows a gross combination weight of 59,000kg. Clearly, with smaller front overhangs, it is possible to achieve the required axle spacing for 60,000kg and even 61,000kg.

Table 7. Performance assessment of two limit cases for 23m truck and long drawbar trailer pro-forma design.

Performance Measure	Acceptability Level	Min CO	Max CO
		Max WB	Min WB
Low Speed Swept Width (m)	Less than 6.95	6.94	6.73
Tail Swing (m) - Load	Less than 0.3	0.07	0.07
Frontal Swing (m)	Less than 0.75	0.51	0.52
Steer-Tyre Friction Demand	Less than 0.50	0.34	0.34
Steady State Low Speed Swept Width (m)	Less than 5.20	5.20	4.99
High Speed Offtracking at 0.2g (m)	Less than 0.46	0.40	0.45
High Speed Offtracking at 0.25g (m)	Less than 0.68	0.58	0.64
Static Rollover Threshold (g)	Greater than 0.35	0.36	0.35
Dynamic Load Transfer Ratio	Less than 0.6 (0.7)	0.43	0.58
Rearward Amplification	Less than 2	1.57	1.79
High Speed Transient Offtracking (m)	Less than 0.6	0.32	0.39
Yaw Damping Ratio (%)	Greater than 15	34	28

In my view, the NZTA should specify a maximum gross combination weight of 59,000kg for these two pro-forma designs for several reasons:

- This weight should be accessible to all the makes of large truck currently available in New Zealand.
- Allowing higher weights will favour trucks with smaller front overhangs. Larger front overhangs are used to create a larger crumple zone which reduces the impact severity in a head-on collision. As well as providing some protection for the occupants of the other vehicle it also reduces the risk of damage to the truck steering system in a head-on collision. A loss of steering control post-impact increases the risk of further impacts and an increase in the severity of the crash outcome.
- Trucks with larger front overhangs have their access steps forward of the front wheel so that they are in line with the cab floor. Trucks with small front overhangs have their access steps behind the front wheel such that the driver must step sideways from the top step to the cab floor. In principle, the direct approach is safer for the driver.
- Under the existing HPMV regime, some trailer manufacturers have developed creative solutions to extract the maximum possible weight capacity from the vehicles. Some of these were not particularly desirable but were permissible. Reducing the scope for these variations by fixing the maximum gross combination weight at a level that is readily achievable should encourage greater standardisation.

Note that the safety benefits listed above are based on theoretical principles. I am not aware of any studies or data that proves these conjectures. Many jurisdictions do not have both sizes of front overhang operating which means that it would be difficult for the comparison to be done. New Zealand would be a good venue for such an analysis, but it would be difficult to extract the relevant data from the crash database.

A draft of this report was reviewed by the NZTA permitting team who felt that effectively combining four pro-forma designs into a single design using a table of allowable combinations of dimensions was too complicated for administration and enforcement purposes. Their preference is to have four separate designs.

From the perspective of the vehicle designer, there are advantages to having all the pro-forma design options on a single worksheet as it makes it much simpler for them to identify which of the available pro-

forma designs is most applicable to their proposed design. Cameron Harris of Domett Trailers has proposed an option where all six truck and trailer designs are included on a single drawing with a table listing the acceptable dimension parameter ranges for each design. The feedback from the NZTA permitting office has indicated that this approach is not acceptable for the permit application process. However, I believe that it is a useful tool for vehicle designers to determine which of the pro-forma designs is applicable to their vehicle configuration. Details of Cameron's proposal are shown in the Appendix to this report.

## CONCLUSIONS

TERNZ was commissioned by the NZTA to develop two new truck and trailer pro-forma designs that satisfy the new PBS requirements. These designs were intended to replace the existing 23m truck and full trailer design and the 23m truck and long trailer design. In fact, the third 23m truck and trailer pro-forma design, which is called the 23m truck and long drawbar design, is very similar to the 23m truck and long trailer design and thus initially we considered two new designs that were intended to be able to replace all three of the existing 23m pro-forma designs.

The new PBS requirements are more demanding on low speed turning performance than the criteria that were used to develop the existing pro-forma designs. The reason for this is that the NZTA wished to reduce the road width taken up by these vehicles on lower speed highway curves. To achieve improved low speed turning performance, it is necessary to reduce the wheelbase of some or all the vehicle units making up the combination.

The existing truck dimension limits were based on the vehicles currently used in New Zealand. Because most of these are imported and their dimensions are determined overseas it was felt that the existing truck dimension limits should not be altered. The only change that has been made is in the way that the forward distance is defined. This approach can better accommodate curved bumper shapes.

In leaving the fundamental truck dimensions unchanged, the only option left is to modify the trailer dimension limits. The maximum dimension values that could be achieved within the performance standards were determined. With the maximum trailer dimensions the limiting factors are low speed performance. However, when smaller dimensions are used, the low speed performance improves but the high-speed performance deteriorates. Therefore, we determined lower limits for the trailer dimensions based on high-speed performance.

Industry feedback on the initial design proposals resulted in some significant changes. Because of fundamental differences in the requirements between the long trailer and the long drawbar configurations it was decided to separate them into two pro-forma designs. The long trailer pro-forma design was also converted to a family of designs by allowing four different combinations of minimum coupling offset and maximum trailer wheelbase. Although it was initially proposed to present these four options as a single pro-forma design, the feedback from the NZTA permitting office indicated that this was too complicated for permitting and enforcement purposes. Thus, these four options are presented as four separate pro-forma designs.

The resulting six pro-forma designs are shown in Figure 4, Figure 5, Figure 9, Figure 7, Figure 8 and Figure 9. At HPMV weights, these designs can all achieve 59 tonnes gross combination weight using all makes of heavy truck. Higher weights are potentially possible with trucks that have small front overhangs which would give these vehicles an economic advantage. However, larger front overhangs are used by manufacturers to enhance the safety of the vehicle and therefore I would recommend setting a maximum gross combination weight of 59 tonnes for these pro-forma designs so that these vehicles are not disadvantaged.

## 23m truck and full-trailer

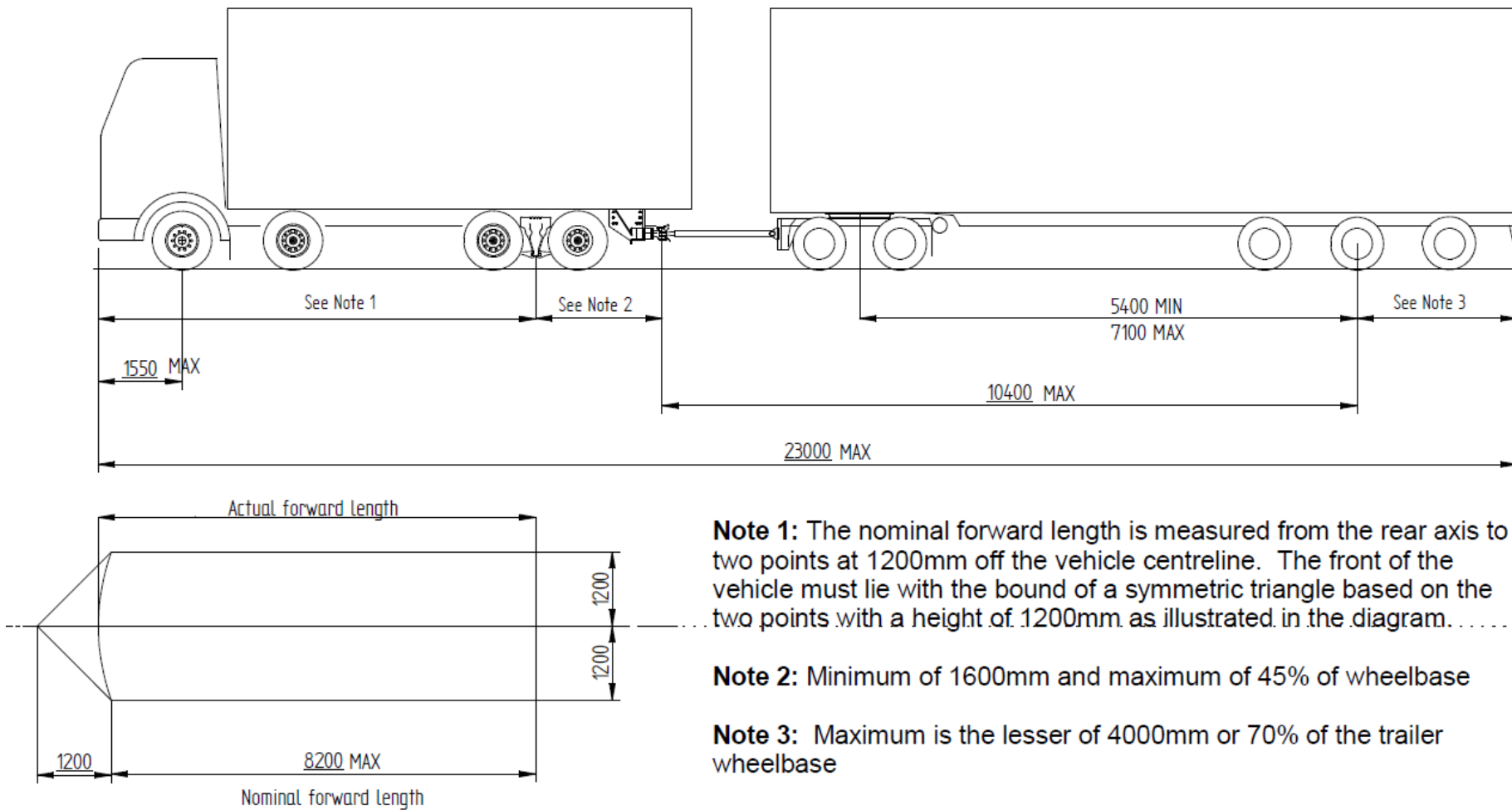


Figure 4. Proposed new 23m truck and trailer pro-forma design.

## 23m Truck and long trailer-1600HO

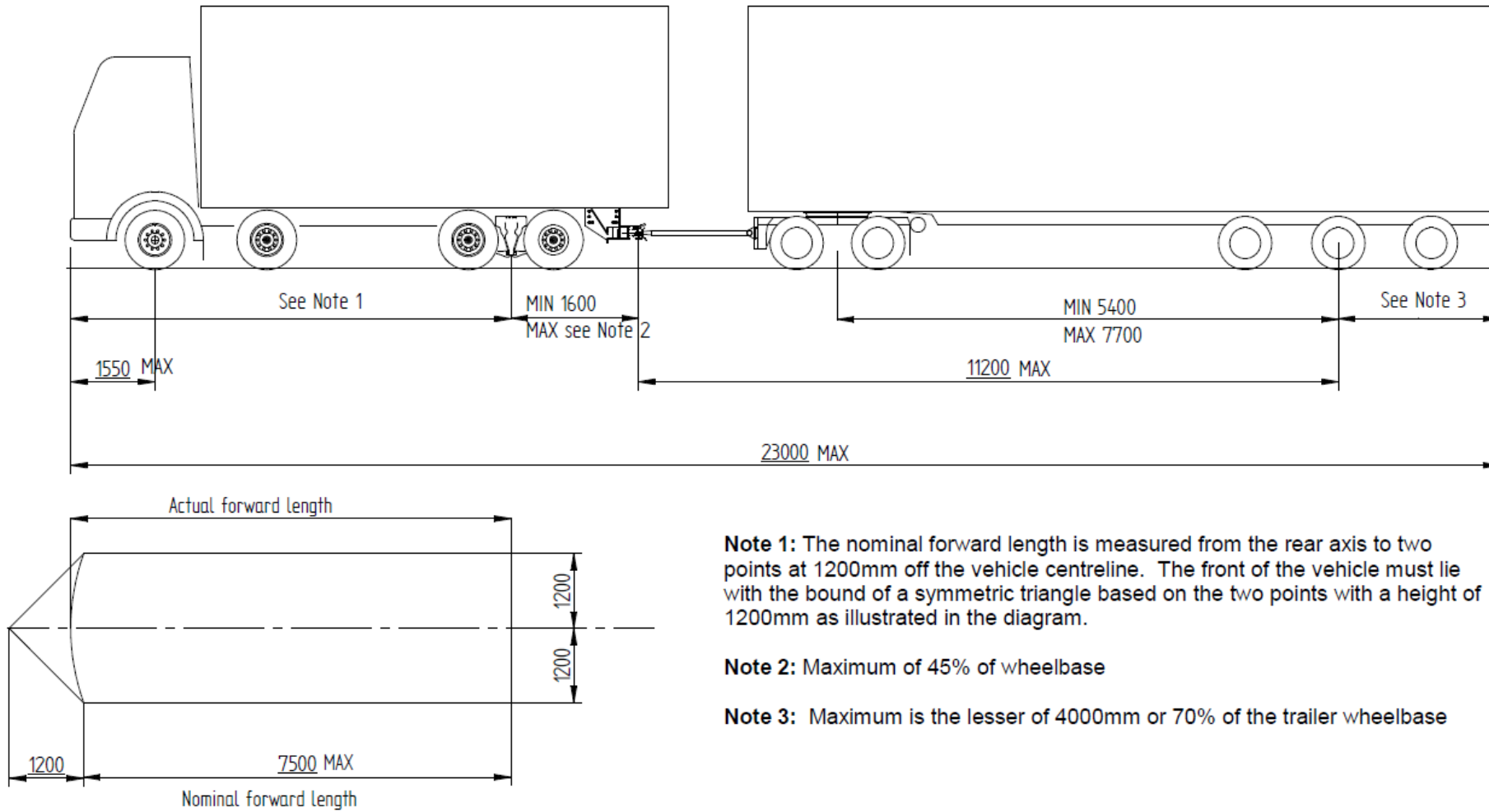


Figure 5. Proposed new 23m truck and long trailer pro-forma design with 1600mm minimum hitch offset.



## 23m Truck and long trailer-1800HO

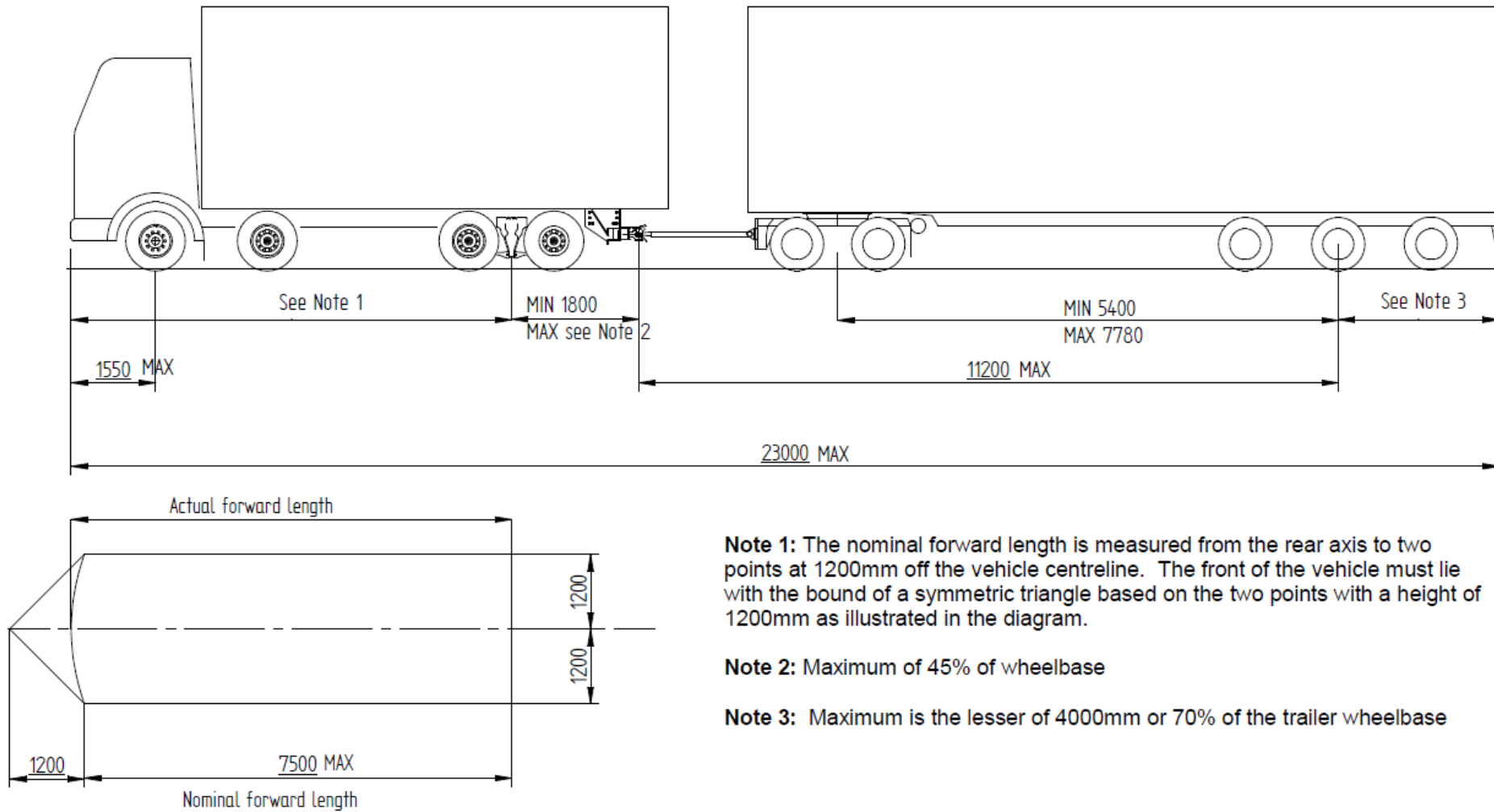


Figure 6. Proposed new 23m truck and long trailer pro-forma design with 1800mm minimum hitch offset.

## 23m Truck and long trailer-2000HO

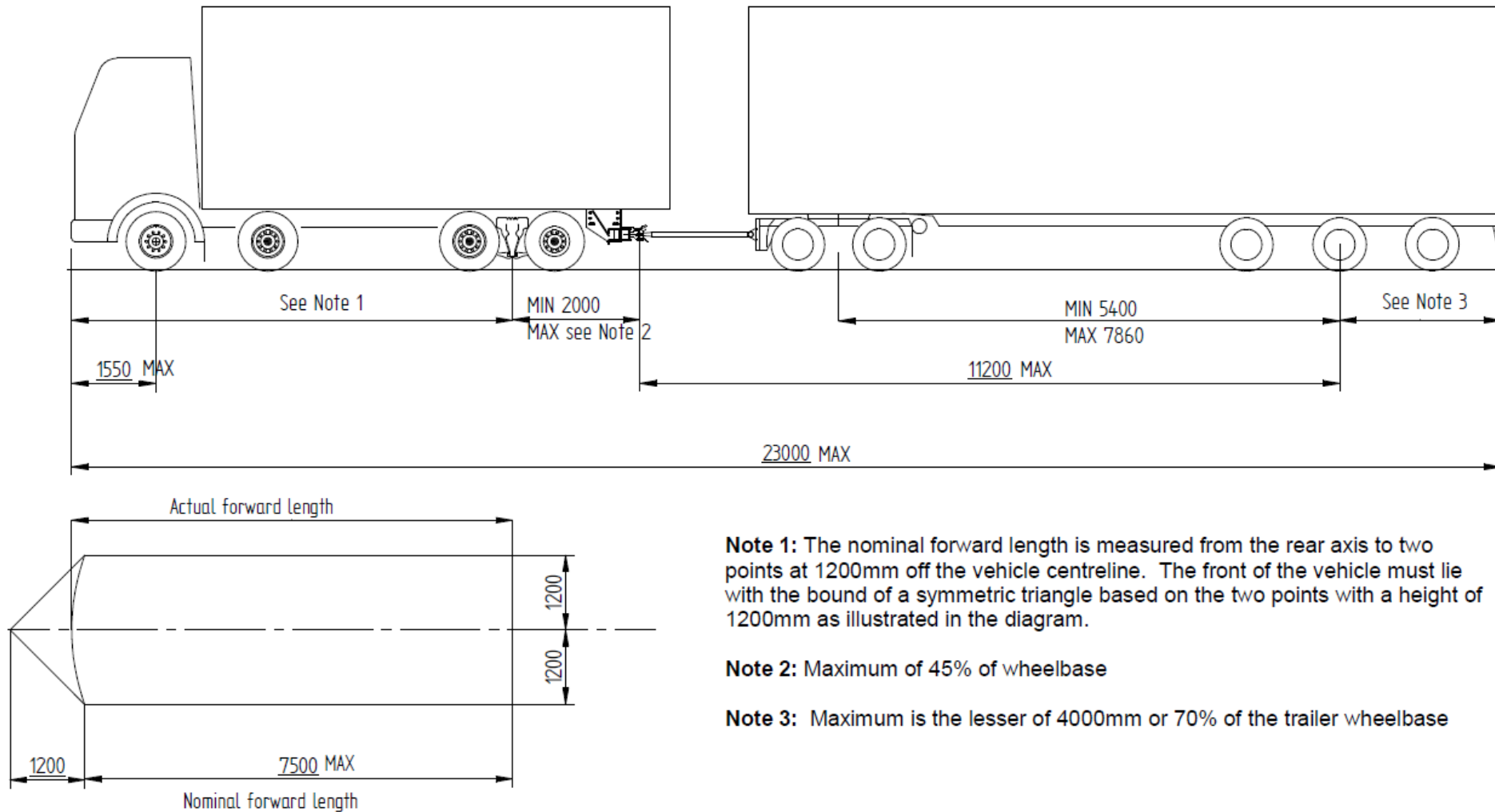


Figure 7. Proposed new 23m truck and long trailer pro-forma design with 2000mm minimum hitch offset.

## 23m Truck and long trailer-2200HO

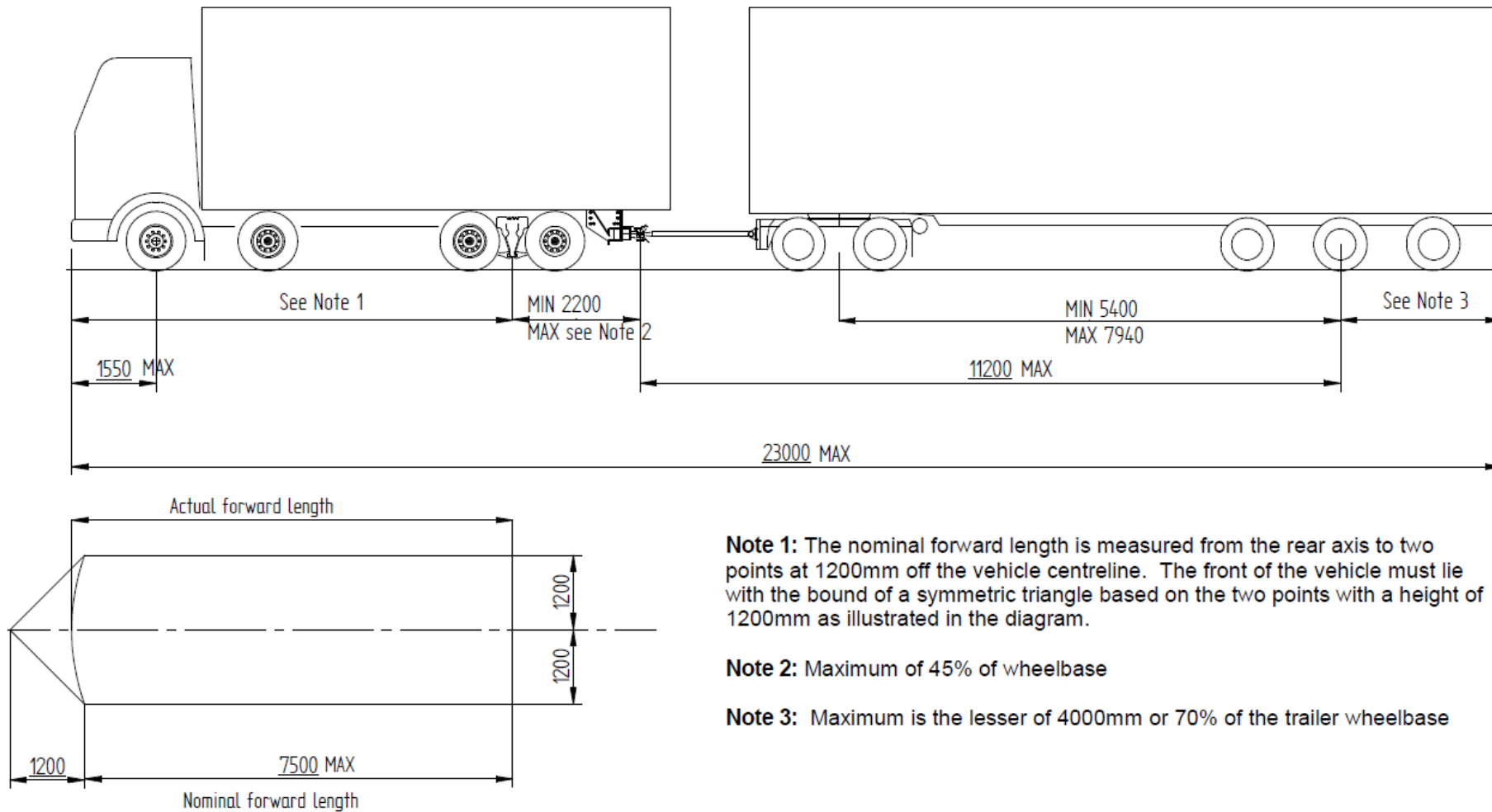


Figure 8. Proposed new 23m truck and long trailer pro-forma design with 2200mm minimum hitch offset.

## 23m Truck and long drawbar trailer

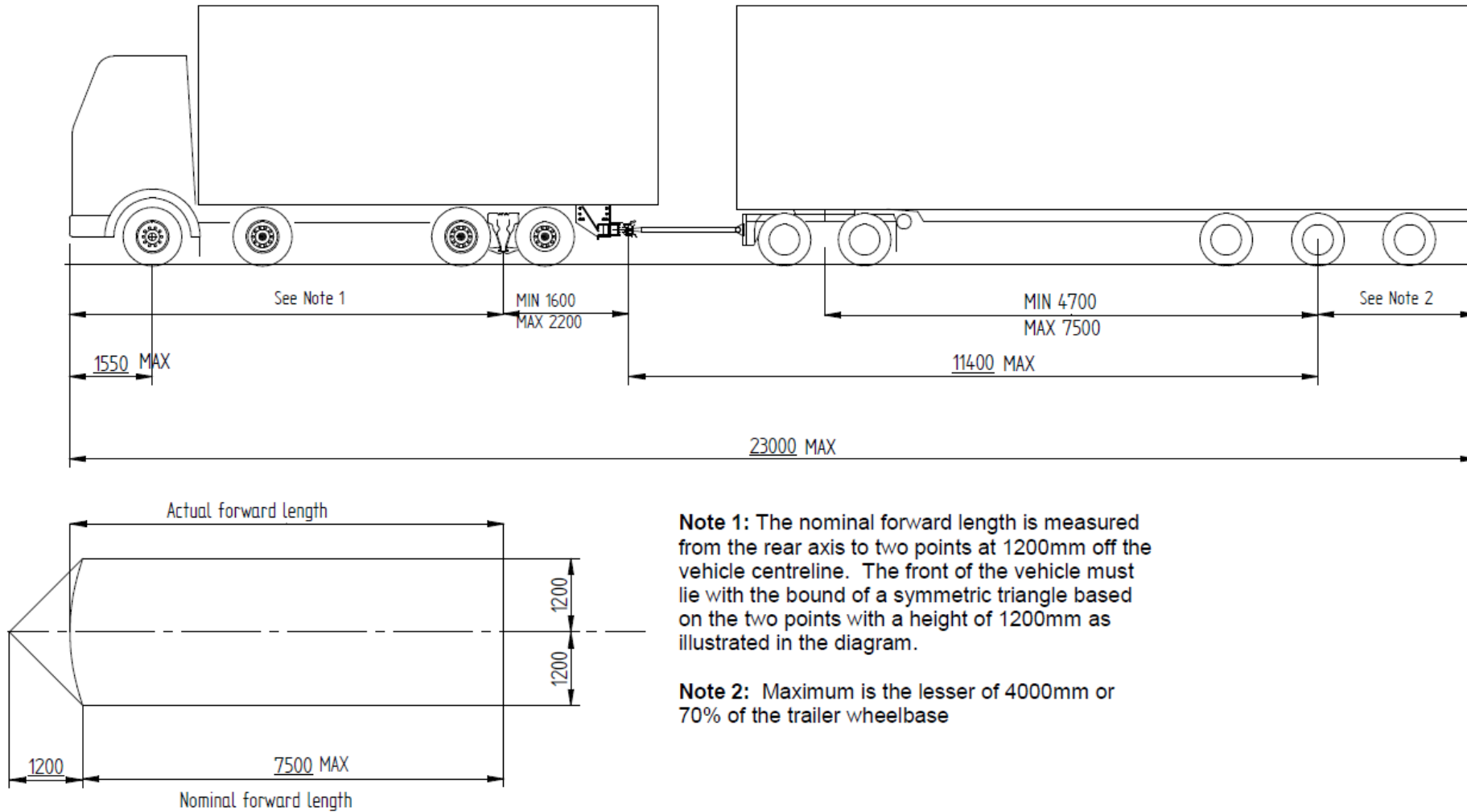


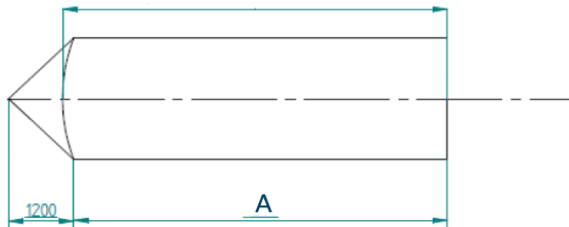
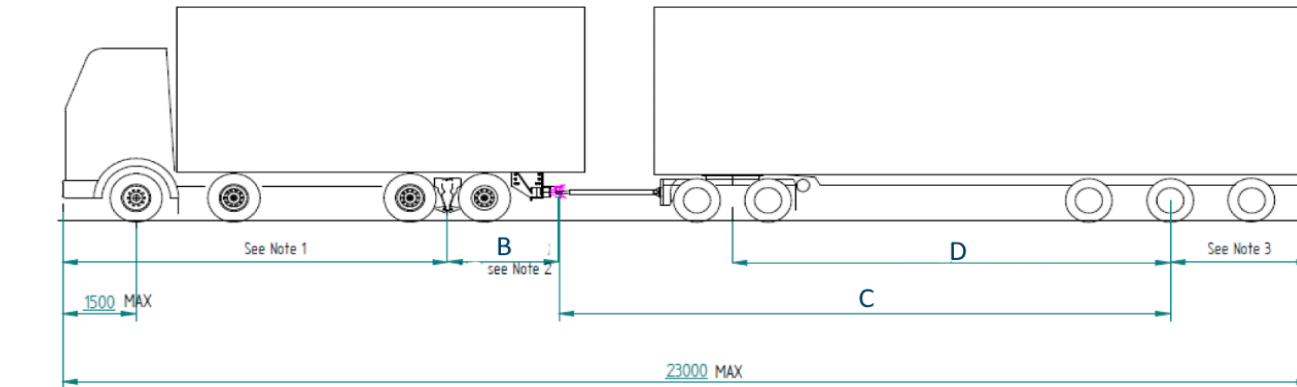
Figure 9. Proposed new 23m truck and long drawbar trailer pro-forma design.

## APPENDIX

As noted in the report, Cameron Harris from Domett Trailers, proposed an option where all six truck and trailer pro-forma designs are included on a single permit application form. His proposed form is shown in Figure 10. The feedback from the NZTA permitting team is that this approach is too complicated for permitting and enforcement officers. However, it is very useful for vehicle designers and builders because it shows all the pro-forma design options on a single sheet. Designers can fill in the A, B, C and D dimension values for their proposed vehicle design and then go to the table and determine whether or not it meets the dimensional requirements of any of the available pro-forma designs. If it does not meet the requirements, it is easy to identify which dimensions need the least modification.

Each row of the table corresponds to one of the six proposed pro-forma designs. Thus, although this form will not be able to be used for the permit application process, I think that the core of it can be a valuable tool for vehicle designers to assist with configuring pro-forma design vehicles. When the design has been finalised the row or rows of the table that the vehicle satisfies immediately identifies which pro-forma design or designs can be used for the permit application.

# HPMV PROFORMA ENTRY CERTIFICATION AND PERMIT APPLICATION DECLARATION



**Note 1:** The nominal forward length is measured from the rear axis to two points at 1200mm off the vehicle centreline. The front of the vehicle must lie with the bound of an symmetric triangle based on the two points with a height of 1200mm as illustrated in the diagram.

**Note 2:** Maximum of 45% of wheelbase

**Note 3:** Maximum is the lesser of 4000mm or 70% of the trailer wheelbase

Proforma	Forward Length		Coupling Overhang		Forward Length		Wheelbase	
	A	B	C	D				
23m Truck & Full Trailer	8,200 Max	1,600 Min	10,400 Max	5,400 Min - 7,100 Max				
23m Truck & Long Trailer A	7,500 Max	1,600 Min	11,200 Max	5,400 Min - 7,700 Max				
23m Truck & Long Trailer B	7,500 Max	1,800 Min	11,200 Max	5,400 Min - 7,780 Max				
23m Truck & Long Trailer C	7,500 Max	2,000 Min	11,200 Max	5,400 Min - 7,840 Max				
23m Truck & Long Trailer D	7,500 Max	2,200 Min	11,200 Max	5,400 Min - 7,940 Max				
23m Truck & Long Drawbar Trailer	7,500 Max	1,600 Min - 2,200 Max	11,400 Max	4,700 Min - 7,500 Max				

The information requested is required to confirm that the vehicle meets the dimension thresholds provided in Waka Kotahi NZ Transport Agency-approved proforma designs for high productivity motor vehicles and to support an application for a High Productivity Motor Vehicle Permit under the Land Transport Rule: Vehicle Dimensions and Mass 2016. Waka Kotahi NZ Transport Agency (and its agents) will hold, store, use and disclose any personal information collected on this form in accordance with the Privacy Act and the Land Transport Act. You are entitled to access, and request the correction of, any readily retrievable personal information held about you by Waka Kotahi NZ Transport Agency. You can do so by writing to us at Private Bag 11777, Palmerston North 4442 or by emailing: [info@nzta.govt.nz](mailto:info@nzta.govt.nz)

I state that, to the best of my knowledge and belief, all the information given for this application is true and correct.

*Warning: It is an offence under the Land Transport Act 1998 to provide information that is known to be false or misleading.*

Name  Company

Signature  Date

Figure 10. Proposed Truck and Trailer Proforma Permit Application Form.