No. 12CV-0112

NZR D-train Sliding 5th Wheel Compound Hitch System and Stinger Semi-trailer

ABSTRACT

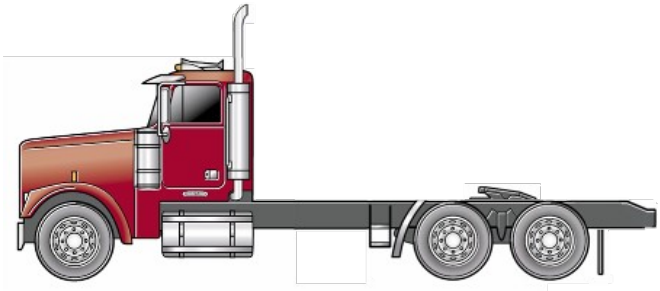
A non-articulating tractor and "stinger" equipped semi-trailer is investigated using patented D-train sliding 5th wheel compound hitch system. The proposed arrangement is designed to reduce "GAP" between the back-of- cab [BOC] and front-of-trailer. The objective is to reduce inter-vehicle turbulence, instability, splash and spray and save fuel. A further objective is to dramatically improve maneuverability and to eliminate the potential for full jackknife. To reduce and eliminate, if possible, damage to the tractor in these often catastrophic circumstances, possibly saving the life of the operator. This new method of coupling tractor/trailers is universal in nature and will not disrupt in-fleet conventional tractors, requiring only minor changes in specifications. The result is an efficient , more stable platform with substantially more maneuverability and possibly safer to operate. Additional advantages involve the potential for an increase in cubic capacity without expanding rig OAL or compromising weight distribution and the bridge formula.

INTRODUCTION

The semi-trailer has become the accepted means for shipment of freight by road. They are a common site, seen as rolling warehouses and are the preferred method for delivering goods and services to the nation. In some cases however, the coincidental nature of the relationship that exists between the tractor and semi-trailer, not the least of which may be the operator, can be compromised. Both vehicles are connected together using either a fixed or sliding 5th wheel and kingpin. This relationship justifies renewed scrutiny of a potentially hazardous connection. Coupling and uncoupling tractor/trailers is a common everyday practice and operators give little thought to it's potential negative effects on stability. Increased traffic congestion and the contrast between large tractor trailers and automobiles, demand renewed scrutiny of this 5th wheel connection.

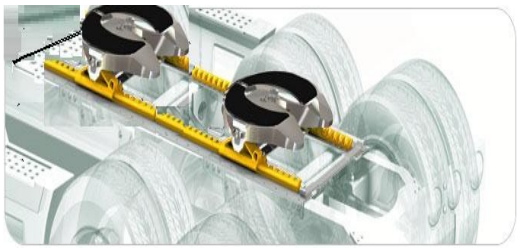
The NZR D-train Sliding 5th Wheel Compound Hitch is designed as an alternative means for connecting tractor trailers and will enhance this relationship. Standard industry components are used with this design and will configure the connectivity of tractor/trailers in a way that is safer and more productive than previously thought possible. A sliding 5th wheel is attached to the tractor chassis frame using extended slider rail for maximum travel. D-trains move the forward travel of the trailer coupler bulkhead to within 15 cm [6]" of the tractor back of cab. [BOC] In addition, the tractor chassis after/frame is extended to insert and overlap the sub-frame 28 cm [11]'. This trailer sub-frame is located between the landing gear legs. The compounding effect of this attachment is to lock the tractor trailer and prevent yaw articulation at the 5th wheel. A turntable is located at the stinger and suitably behind the landing gear location. Articulation of the semi-trailer is re-located to the stinger, rear of the landing gear with stinger turntable rotation limited to 52 degrees a bonus in that full jackknife is no longer possible. As the stinger design location and pivot has shifted to the center of the rig and to the rear a 40% improvement in maneuverability is the result.

Providing a solution to inter-vehicle "GAP" and the elimination the tractor single point hitch is a priority for this design. With reduced "GAP" the potential exists for 5% fuel saving, never-the-less the universal tractor Fig.1is not affected. Specifying various [BBC] dimensions, with or without sleeper cab, the universal tractor specification is maintained with trailer swing clearance.



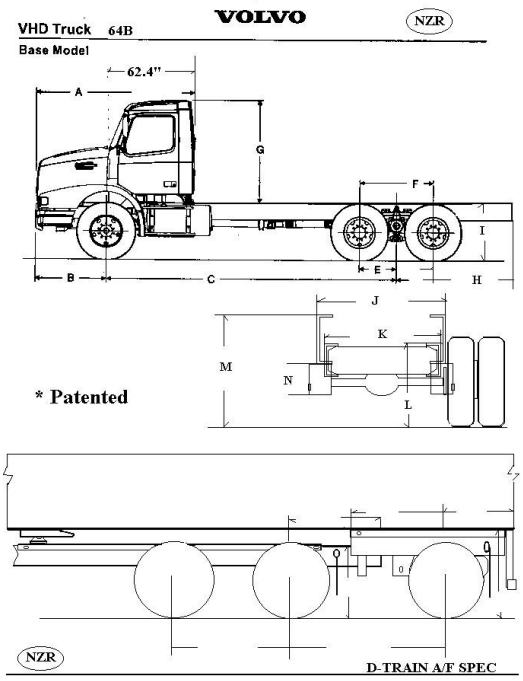
Conventional Day-Cab Tractor
Figure 1

Closing the "GAP" while extending the tractor wheelbase, the slider rail will re-locate the 5th wheel and front-of-trailer to a position close to the tractor cab [BOC]. A new dimension developed for "GAP" is 15.2 cm [6]" cab-to-trailer. The compounding affect of this hitch is accomplished by a sub-frame glove assembly attached to the trailer frame and landing gear. The tractor chassis and after/frame is extended to engage and overlap 28 cm [11]" the sub-frame. Swing clearance for conventional semi-trailer is maintained. The Stinger trailer landing gear is modified to incorporate a sliding mechanism suitable for re-location behind the rear drive axle. As an alternative a folding landing gear may be used in certain applications such as with dump trucks. In addition, an air-ride suspension axle may be added to the trailer as a pusher and located 1.37 -1.52 m [54-60]" behind the drive axle and landing gear.



Extended Slider Rail
Figure 2

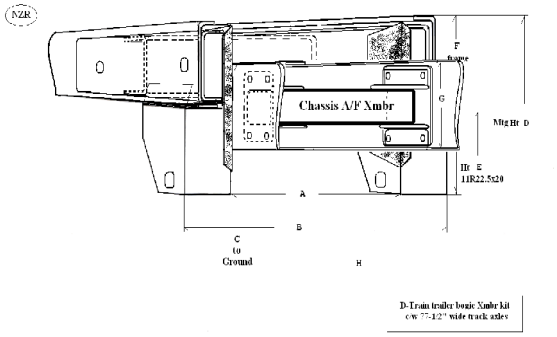
An extended 5th wheel slider rail positions the semi-trailer coupler forward and close to the [BOC]. Inter-vehicle "GAP" is almost completely eliminated with a reduction of approximately 1.37 m [4.5]' and may represent additional skids with each load. A standard slider assembly Fig.2 is available from various OEM manufacturers and is used to meet D-train specifications. With appropriate cab-to-axle [CA] 6.5m [262]" specification and tractor 60" sleeper, BBC 4.57m [15]' and forward slider travel for [BOC] clearance of 15.2 cm [6]" a 152cm [60]" slider 5th wheel position a 18.2 m [60]' semi-trailer length may be facilitated 23 m [75]' OAL. This configuration will maneuver inside a conventional tractor with 53' semi-trailer.



Constructors Spec Sheet
Figure 3

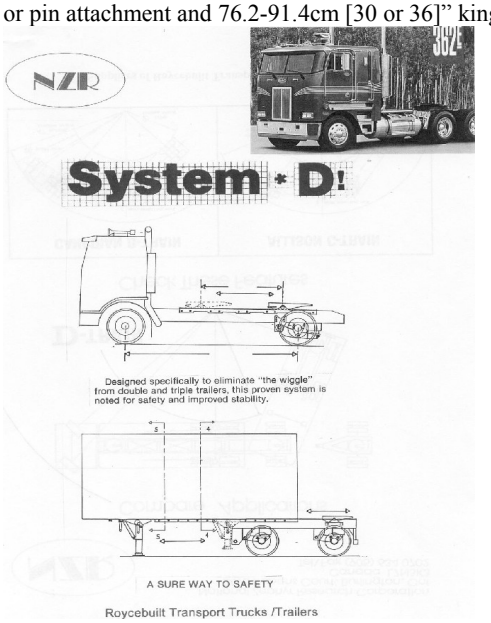
The tridem pusher arrangement Fig.3 is similar to a tag axle equipped with air suspension and is a trailer attachment. The air suspension may be used to lift and lower the trailer without the landing gear. The D-train tractor is connected as follows: The tractor 5th wheel is connected to the kingpin and backed with the chassis A/F captured between the landing gear legs. The stinger sub-frame guides the tractor chassis after/frame into a gloved position. In this process, the 5th wheel slider moves forward to the stops and is locked in place. The after-frame remains free in pitch with a minimum 5 degrees of upward travel. A typical semi-trailer having 1.20 m [47.5]" coupler and tractor frame height 1.04 m [41]". These dimensions and mated components are over designed to perform in a low stress environment. However. friction plates either side of the sub-frame assembly are provided to receive the tractor after/frame and reduce chassis wear and tear.

Specification sheet Fig.3 outline the critical specifications for a tandem tractor with or without, the higher GCW pusher tridem. A 28 cm [11]" overlap of the sub-frame provides for secure positioning without pins or locks. A union of compatible dimensions acts to favor this design. The typical landing gear (not shown) is positioned between the last axle of the tractor and ahead of the stinger. When installed, the trailer pusher axle provides for increased GAWR.



Tractor After/Frame Glove Assembly
Figure 4

A gloved sub-assembly Fig.4 is installed to receive a standard tractor after/frame with overlap of 27.9 cm [11]". There are no locks or pin attachment and 76.2-91.4cm [30 or 36]" kingpin settings are maintained.



5th Wheel & Landing Gear
Figure 5

Improvements in stability associated with this type of hitch may be of benefit to "double" and "triple" trailers. The use of a conventional or cab-over [CO] tractor Fig.5 with 8.7 m [28.5]' double trailers or sliding "B" tandem bogie [Second trailer not shown] has proven to reduce yaw oscillation. [SAE 831162] The most common double trailer rig uses an "A" type converter dolly and has (3) three points of articulation. The B and C double trailers has (2) two points of articulation. By contrast the D-train 5th wheel compound hitch system and double trailers, uses (1) one articulation point which is the stinger!

The relative jackknife tendencies of stinger steered automobile transporters simulate an enhanced safety and stability for auto haulers 'and as a result, have achieved extended length approval 22.8m [75]' and 24.99m [82' OAL with overhand.

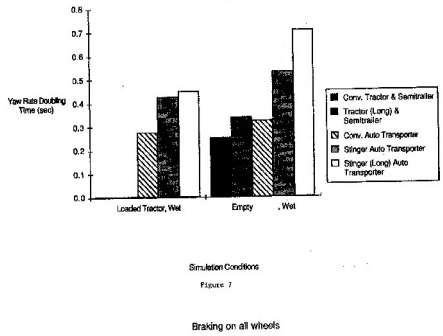


Figure 6

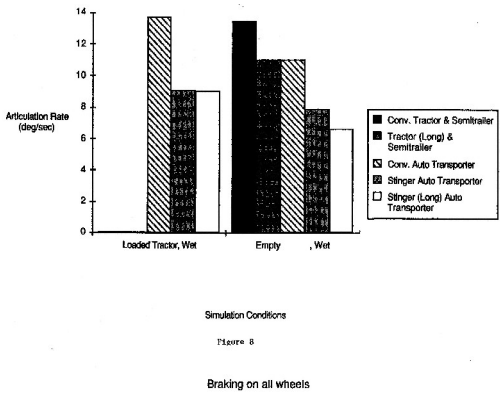


Figure 7

The propensity to Jackknife is an important safety criteria for tractor trailers and is long overdue target and has become a target for marketing of electronic stability systems. ESP systems offered by Wabco, Bendix and others work to prevent catastrophic events such as a jackknife. Nevertheless, reducing the propensity for jackknife and subsequent rollover by improving the specifications by expanding the use of stingers may be an advantage.

Though the stinger concept is not new nevertheless, recent simulation studies suggest they offer a substantial improvement to stability this according to the University of Michigan Transportation Research [Umtri-85-53]. And this is being achieved with the longer tractors associated with stingers. Applying longer tractors with stinger equipped semi-trailers may contribute to improve overall stability. Findings indicate for example; stinger steered auto carriers are superior to conventional tractor trailers and this is partly due to a longer tractor associated with the stinger. The 22.8m [75]' stinger configuration is predicted better able to avoid a jackknife than is the shorter 19.8m [65]' semi-trailer with conventional 5th wheel location.

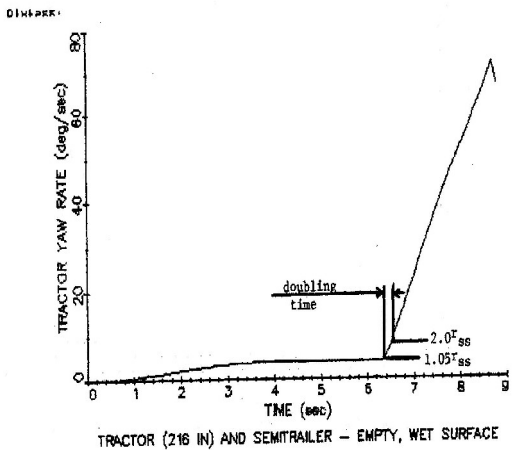
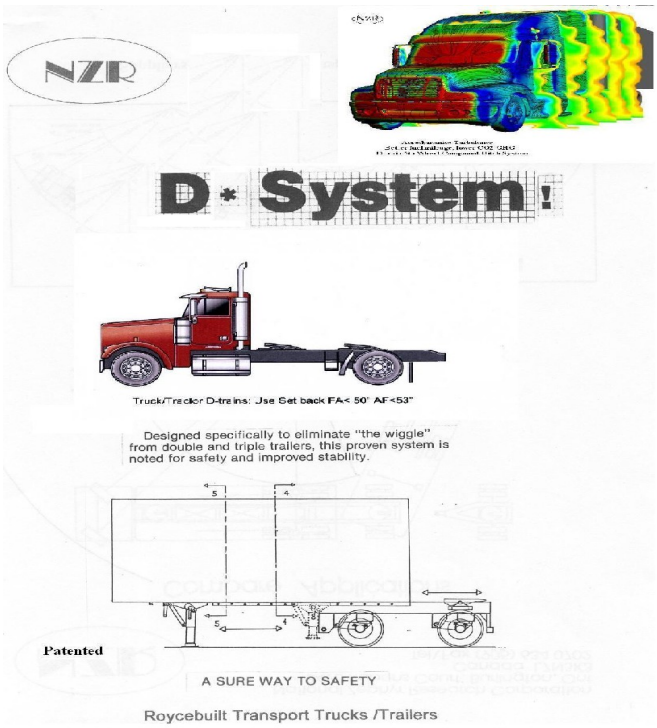


Figure 8

Results of simulation are dramatically in favor of the stinger steered vehicles when normal braking is employed. The reason for this is stinger steered vehicles have a more favorable arrangement of vertical load than other vehicles when empty. This gives the stinger steered vehicle a definite advantage which is clearly indicated in the bar charts Fig.6 and Fig 7. The difference between the jackknifing tendencies of a 19.8m [65]' stinger-steered auto transporter and a conventional tractor with 548.6cm [216]' wheelbase however, is very small. An examination of the simulation results Fig. 8 indicate the worst vehicle [the one with the greatest jackknife tendency] is that the conventional tractor semi-trailer having a wheelbase of 365.7cm [144]" inches and standard 5th wheel position.

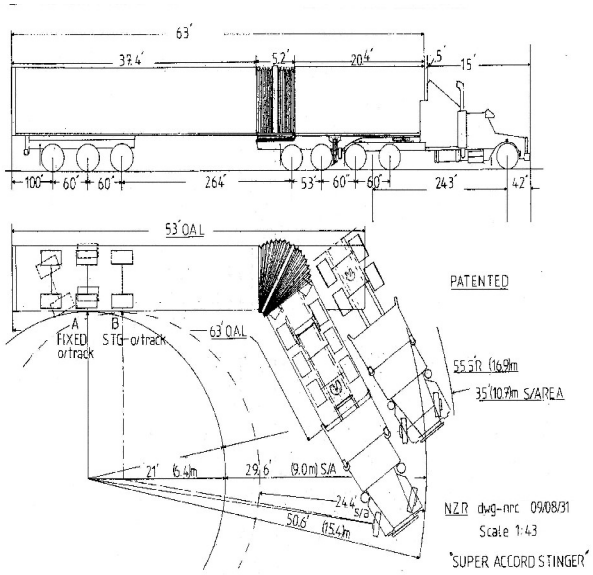


D-Train Double & D/B Trailer
Figure 9

A conventional tractor equipped D-train and stinger semi-trailer equipped with optional pusher axle Fig.9. This rig turning ability is exceptional and even meet the mandated European off-tracking formulae with 16.2m [53]' semi-trailer. An equal axle spread 1.37 x 1.37 m [54x54]" specified with a pusher axle for increased gross axle weight ratings [GAWR] and may be an advantage.

D-train Stinger Cab Over tractor
Figure 10

Specification established by the EU and German "BO-Kraftkreis" with min/max off-tracking prescribed [6.3 m [20.6]' inner radius and 12.5m [41]'outer radius] are required, all tractor/trailers must must meet this formula. The North American D-train with sliding 5th wheel compound hitch and stinger semi-trailer [16.5 m [53]' will meet this formula. Fig.10



Off-tracking Comparison Chart
Figure 11

The effect of a D-train compound hitch and stinger steered semi-trailer with minimum “Gap” for off-tracking comparison with 16.2m [53]' similar rig Fig 11. The longer “Super-Accord” D-train tractor with 19 m [63]' stinger trailer will turn inside the standard tractor/trailer 16.2m [53] due to improved maneuvering while using less swept area; [9.0 m [29.6]' compared to 10.7 m [35'] OAL 20.8 m [68.5]’and 23.9 m [78.5]’ respectively.

D-train stingers, although limited to 52 degrees of rotation offer adequate off-tracking ability. Nevertheless, rotation will prevent the tractor cab from impacting the trailer in a jackknife. A flexible load resistant flexible skirt is installed as part of the inter-vehicl van stinger. These skirts are commonly used with articulated buses, streetcars and trains. They perform a similar load bearing task as with curtain-side trailers. Articulated bus chassis 22.8 m [75]’ OAL are commonly seen negotiating 90 degree turns on City streets. The D-train equipped tractor and stinger semi-trailer having 52 degree of articulation will out-maneuver a 16.2m [53]' semi-trailer. Fig.11

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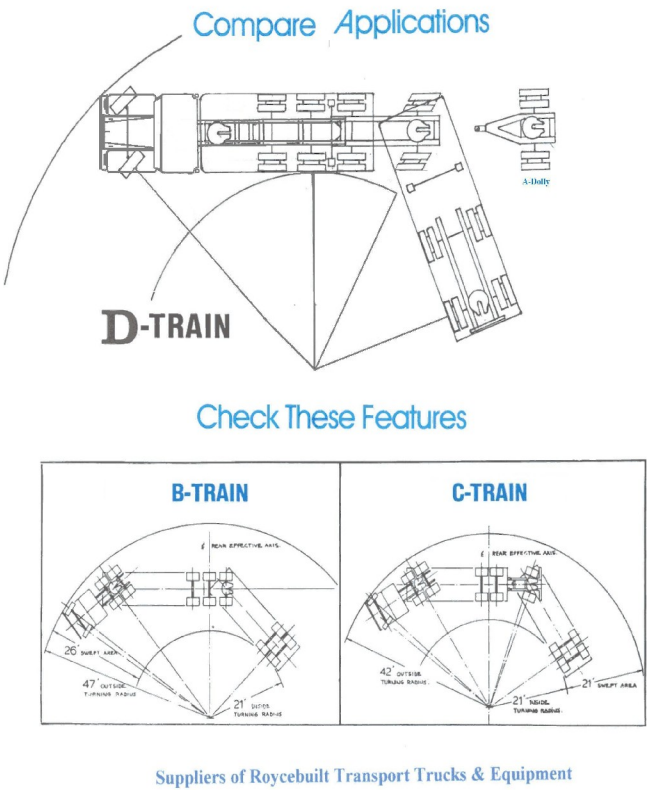
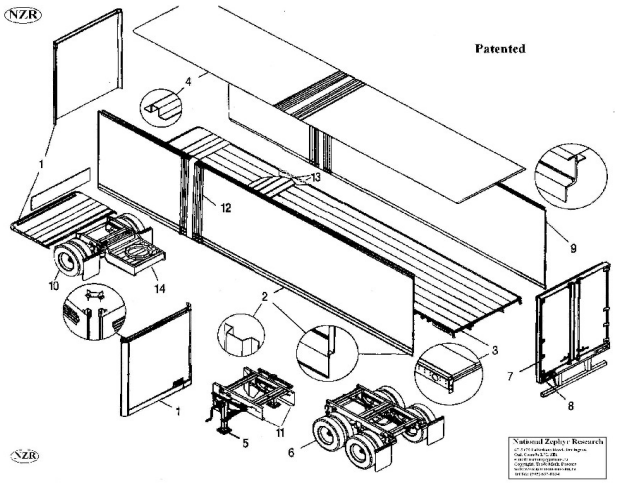


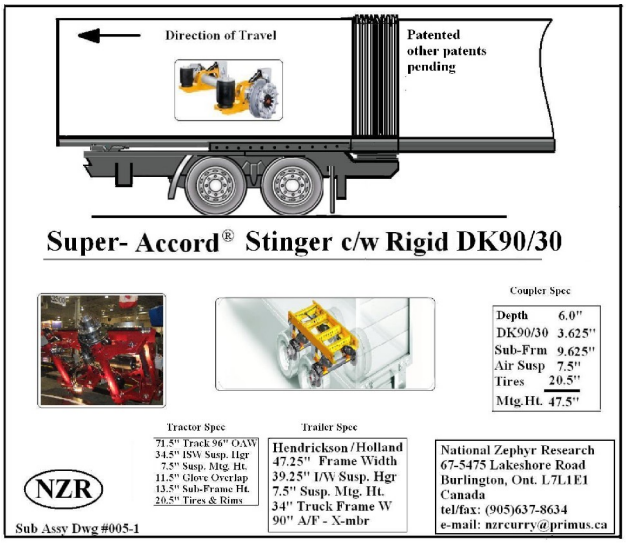
A/B/C Train Connectivity
Figure 12

A common configurations on the road today are B and C trains Fig.12. They have improved the handling and stability of double and triples trailers. The elimination of articulation points has, according to and the Transportation Agency of Saskatchewan [SAE 831164] has noted the improved safety with C-trains and having undergone many thousands of trouble free miles also indicate an improve stability. The D-train compound hitch equipped tractor and stinger semi-trailer may offer similar benefit according to such research. And the application and use of this principle may offer improved safety and performance for protecting equipment from loss of control or jackknife in the future. To eliminate articulation from the tractor chassis and move the articulation to the stinger will pay dividends, possibly even increase productivity. Return on investment ROI for D-train 5th wheel compound hitch and stinger trailers is in the order of three to five years, this is based on the average application and having a 10-15 year life cycle.



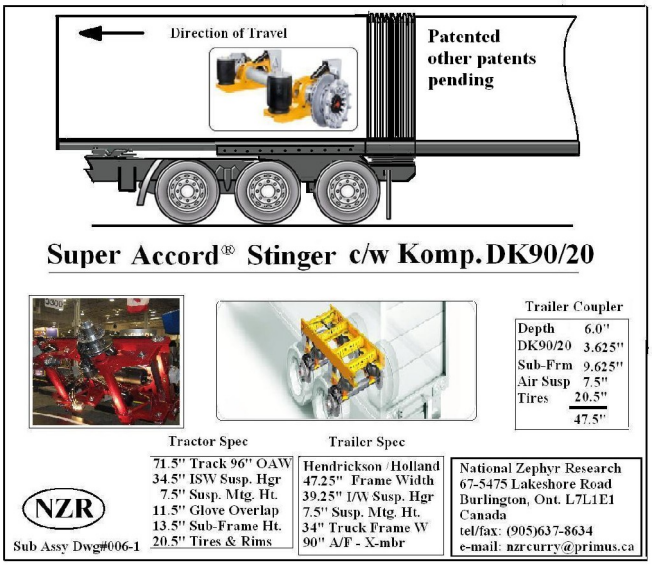
Exploded View Stinger Van trailer
Figure 13

An exploded view of a conventional van semi-trailer and stinger sub-frame assembly complete with landing gear Fig.13. Taking advantage of reduced "GAP" by adding 1.37 m [4.5]' to the length of the trailer may gain additional skids. Overall length of a D-train tractor trailer 22.25 m [73.0]' "GAP" and may allow for increased legal trailer length to 17.3 m [57]' even 18.3m [60]' with sleeper cab tractor.



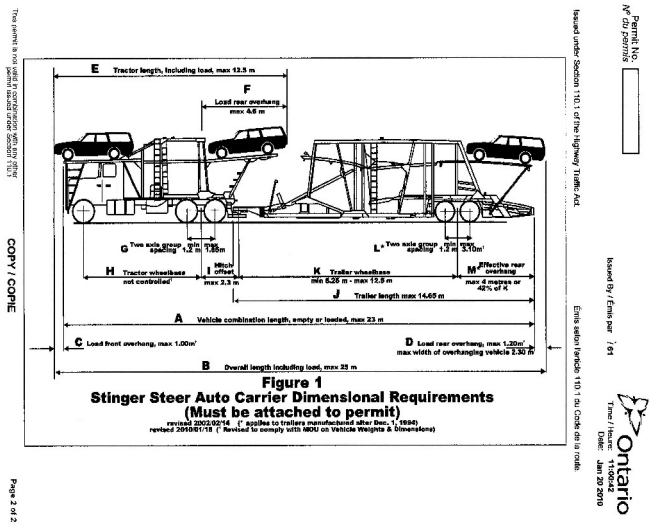
Tractor chassis inserted and Stinger Trailer
Figure 14

When transitioning the tractor chassis to the stinger glove sub-frame assembly, the tractor chassis A/F will be guided from the longitudinal, straight ahead into a fixed position preventing articulation. A minimum five degrees pitch is maintained to overcome roadway obstacles. Coupling the rig at a tangent, the 5th wheel is connected to the kingpin and transitioned aft, the tractor is aligned for compound coupling. A side elevation view of the two mated vehicles having been coupled Fig.14 and Fig.15. [Standard specifications] A tandem yard jockey or shunt tractor when connected to a stinger semi-trailer performs in a similar manner as with a standard semi-trailer. However, 5th wheel wedge-lock may be necessary when using a single axle yard tractors.



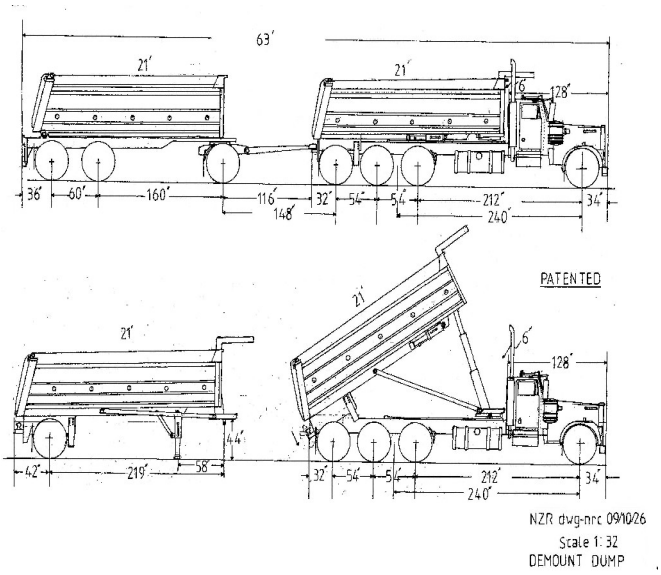
Tractor inserted with Stinger Tridem
Figure 15

A tridem trailer as configured Fig.15 and with additional pusher axle, the higher gross carrying weight [GCW] may require a compensator. With certain terrain an extended length van semi-trailer will roll undergo torque to the sidewall in a 45° degree turn due to the larger load [GCW]. This tension can be relieved by using a compensator stinger assembly.



Stinger Equipped Car Carrier
Figure 16

Proof of concept may be gained from car carrier industries years of experience using stinger tractor/trailers [UMTRI-85-53] and papers. [SAE 831162 and 831164] Stinger tractors have transported expensive automobiles all over north America for many years and continue to do so. They are common around Cities and Towns, they benefit from improves maneuverability offer by stinger location. There are a large number of auto carrier stinger tractor trailers in use across the country and unlike the semi-trailer, benefit from extended length. [24.9 m [82]' OAL] In addition auto carrier stinger trailers are permitted ingress and egress apparently, with few restrictions under Federal and State law. They are permitted longer overhang and longer wheelbase tractors. Similarly equipped tractors with compound hitch and with stinger semi-trailer may also garner support and privilege for extended length and GCWR. Something that is sorely needed for a challenged truck transport industry and a fifty percent increase in capacity required by 2020.



D-Train Dump
Figure 17

Aggregate and refuse vocational trucks will benefit from D-trains and the added flexibility offered. Similarly, snow removal and municipal utility trucks may take advantage of the added flexibility offered by a 3:1 body and chassis ratio with compound hitch. A system that allows for speedy transition from one vocation to another. Fig 17.

Super D-train Equipped Dump
Figure 18

Super off-road vocational trucks require a heavier body that will increase capacity and enhanced power-to-weight ratios and save fuel. These larger trucks are designed to increase payload capacity in off/road applications a 3:1 ratio can have cost saving benefit, possibly reducing fleet capital cost Fig.18 Improved serviceability will be the result of quick change bodies. The compound hitch for dumps when used in either on or off-road applications can facilitate a full 90 degree or greater slow speed articulation with the added pitch necessary when conditions and terrain demand.

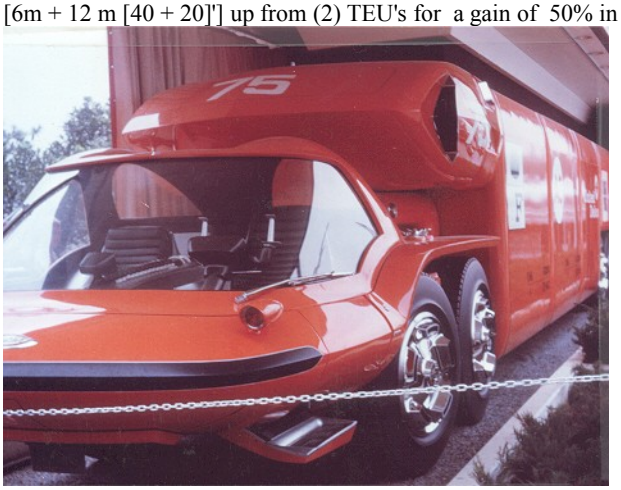
CONCLUSION

Toward a safer more profitable tractor/trailer configuration: The D-train sliding 5th wheel compound hitch and stinger semi-trailer appear to be consistent with a NHTSA, FMCSA mandate “Toward a safer tractor trailer”. A new system for connectivity, a platform which may enhance compliance improving stopping distances, directional stability, handling and the safety of tractor trailers.

The Trucking Industry is being forced to innovate at a time when competition for business is growing along with escalating costs. Industry analysts are adjusting specifications to meet customer demand while looking for ways to save on fuel costs. [One of the larger expenses associated with trucking] Industry manufacturer's are maximizing aerodynamics and trailer innovations such as, single tires, side skirts and boat tails, all in order to save fuel. Never-the-less, there remains the question of a shortage of qualified operators. Ergonomics on the other hand, while not necessarily saving fuel, offers little advancement to cost savings and safety, yet interior cab ergonomics and the design of tractor trailer configurations may be the key to attracting professional operators, without which, many fleets will not survive. D-trains provide an opportunity for ergonomics to one again take precedent. Creating a platform for a renewed and sustained interest of career professional.

Regulation and the introduction of CARB, GHG abatement continues to challenge. Some of these 2012 challengers are as follows: Stopping distances, Hours of Service, EOBR's, CO2 abatement, DEF additives, Speed limiters, Hands free cell phones and CB use. These all militate against the confidence and enhanced profitability of industry and the career of the professional tractor trailer operator. Ergonomics and the introduction of an effective “GAP” mitigation program along with education as to the reduction of articulation points will improve this situation. A new industry option for D-train compound hitch equipped tractor and stinger semi-trailers will recreate the style of Leland James. Possibly loose a raft of tractor semi-trailer design configurations having ergonomics at the forefront of cab design. Thus paving the way toward a renewed initiative, one in which ergonomics plays a larger roll in trucking cab design. An operator friendly rig employing ergonomics, an iteration that bestows renewed status on the career professional who's job it is, to safely manage strategic freight volume worth many billions of dollars.

Further, a growing component of trucking is it's association with containerization. Port authorities are expanding their rail yards, they are being forced to build inland container ports in order to cope. Ever larger ships are on the horizon that will further exacerbate an already large problem. Clearing containers from the port is vital to the efficiency and turn-around times for such ships. Improving efficiency of the dray-age component in these ports and adding an additional 6 m [20]' container to the trailer is an advantage. Profit and Loss [P&L] and the bottom line are of continuing concern as operating ratio's erode. Today, operating ratio's approximate 94% and by necessity are supplemented with fuel surcharges. These ratio's may be reduced to the 82% range with a more appropriately design configuration. A change in the specification to a D-train stinger tractor container chassis will facilitate three (3) TEU's [6m + 12 m [40 + 20]'] up from (2) TEU's for a gain of 50% in dray-age capacity.



GM Bison Side loader Concept
Figure 19

The ergonomic design of an earlier concept offered by Bison, division of General Motors Fig.19 This vehicle was purpose built for display during the 1964 New York Worlds Fair. [Ford Motor Company offered a similar concept] Apparently, engineers at the time considered ergonomics an import component and part of the equation for attracting operators to the profession. This design concept, was a candidate for future tractor semi-trailer application projected for launch 1975. Today's tractor trailers designs are no-doubt effective however, the various regulatory constraints are having a debilitating effect on trucking industry and compromising tractor trailer design. We have placed this vital industry in a straight jacket, stifling initiative and operator acceptance and design. Apparently, gone are the days of Leland James, he took the initiative, engaged engineers to design his new concept cab over engine cab used ergonomics to drive capacity. Leland founded the Freightliner corporation on the strength of cab over design, what happened. Today's incremental-ism along with brand and market driven economy the financial crisis, all are bent on killing a renewal of ergonomic design. The apparent lack of engineering freedom in truck design is stifling ergonomics while the trucking industry increasing demand for operators is against the ropes, are the two connected. The cost of regulation has played a roll no-doubt and may be one of the reasons truck designers have shunned ergonomics as an after-thought. The introduction of this D-train compound hitch and stinger trailer is a link back to the spirit of Leland James. His creative ergonomic design offer up a new tractor trailer concept for improved capacity. D-trains offer the same opportunity for increased capacity as did Leland James. To build, under one roof, future tractor stinger semi-trailers based on ergonomic design as did Leland James.

ACKNOWLEDGEMENT

National Zephyr Research is dedicated to the design of on/off road transportation systems. Patented products which are often licensed to others. These products attempt to improve transportation safety and the efficient movement of goods and services. A mandate that could be important to a truck freight industry where the cost-of-operation continues to climb even as freight volumes are expected to double by 2020. Not incidental to this situation is the difficulty experienced by transport companies in attracting professional operators. [Drivers] Of concern is the enthusiasm for incremental design and economic constraints placed on engineers vis-a-vis ergonomics. Further the imposed bridge laws, ingress and egress rules, overall length limits, stopping distances, speed limiters, hours of service, GHG emissions and the greening of engines. All play a roll to deflect ergonomic design in favor of electronics and incremental-ism. The never ending search for fuel savings, all conspire to frustrate the professional vehicle operator's workplace.

In search of a new paradigm without constraint, is our mission, a new platform on which to innovate the possible. To advance the cause of trucking and apply information garnered from years of experience in manufacturing, marketing and applications across the western world. As innovators of a number of these and other related products, some of which are written into highway regulation. We have established a track record with product such as; heavy haulage steering trailers, multi-axle steering trailers, twin draw-bar converter dollies, "Gap" reduction and elimination of articulation points. These products have hard-won support among academics and researchers, they have proven worthy of support and investment. As an alternatives to the single point "A" train converter for doubles the C-train is now an established configurations. The collaborative introduction of Forced steering axles, Command steering and Self steering axles all are committed to the principle of eliminating articulation having published operating manuals for many of these products and their application, the initiative was taken to attack inter-vehicle "GAP" and the failings of the conventional 5th wheel connection for tractor trailers. The need to question this coincidental relationship and invent a better method in the 21st century, "the non-articulating tractor and stinger semi-trailer". Clearly, the way forward was to design a new method of tractor semi-trailer connection one which offered the potential for new and improved ergonomics. A concept that incorporated rear mounted engines opening the way to a modern flat-floor, step-in cab, the reduction of "GAP" and the elimination of full jackknife. Could a profitable design afford these changes and re-vitalize industry attracting much needed profession operators, only time will tell.

DEFINITIONS/ABBREVIATIONS

BOC	Back of Cab
BBC	Bumper to Back of Cab
OAL	Overall Length
GVW	Gross Vehicle Weight
GCW	Gross Carrying Weight
GAWR	Gross Axle Weight Rating
A/F	After Frame
CA	Cab to Axle
EOBR	Electronic o/b Recorders
C/O	Cab over Engine
DEF	Diesel Exhaust Fluid
GAP	Inter-Vehicle Distance
D-TRAIN	5th Wheel Compound Hitch
CARB	Calif. Air Abatement Board
NHTSA	Nat. Trans. Safety Board
FMCSA	Fed. Motor Carrier Safety Assoc.
NRC	National Research Council
NZR	National Zephyr Research

REFERENCE

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