

## A STUDY OF THE INTRODUCTION OF HIGH PRODUCTIVITY VEHICLES INTO URUGUAY



PhD from the Institute of Transport and Logistics of the University of Sydney, MSc in Logistics of Federal University of Santa Catarina (Brazil) and Industrial Engineer (Argentina). Director of Instituto BioGesta and Partner of BrAle Consulting, instructor of the Bitrain Drivers School (EMaBi). Ale is recognized in Spanish speaking countries for being one of the engines behind the safe and sustainable implementation of HPVs in the region.

A EFRÓN  
[alejandra@braleconsulting.com](mailto:alejandra@braleconsulting.com)  
BrAle /EMaBi  
Argentina



Engineer graduated in Melbourne University, Bob Pearson is one of Australia's leading experts on road vehicle policy and regulation, with substantial expertise in areas such as vehicle productivity, vehicle infrastructure-interaction, road safety, regulation and compliance. He has advised many Latin American governments on the implementation of HPVs.

B. PEARSON  
[bobp@ptrc.com.au](mailto:bobp@ptrc.com.au)  
Pearson Transport Research Centre – PTRC  
Australia

### Abstract

In 2017, the Ministry of Transport and Public Works (MTO) of Uruguay received a request from the private sector to extend the authorization to drive with 57 ton Gross Train Weight (GTW) bitrains to other corridors of the national road network, which were authorized only in two specific forestry corridors since 2011, as well as to allow the circulation of other larger and heavier combinations. The request triggered a thorough two phases feasibility study which involved a team of expert consultants from different countries working together with technicians from the MTO, as the response given by the Uruguayan government to the industry's request without compromising community safety. This paper is a summary of the project to introduce High Performance Vehicles (HPVs) in Uruguay. The possibility of replicating the implementation procedure to countries with similar cultural behaviors is left for discussion at the HVTT15 Symposium.

**Keywords:** high performance vehicles, implementation, regulation, Uruguay

## 1. Introduction

In 2011, two specific corridors for the circulation of cargo vehicles known as bitrains (B-Doubles or B-trains in other parts of the world) were authorized for the forestry industry in Uruguay. These bitrains can carry 57 tons Gross Vehicle Weight (GVW) instead of the 45 tons conventional heavy vehicles permitted. The regulations regarding the use of technological elements to ensure greater safety for the circulation of these vehicles are much more rigorous than those applied for conventional trucks. These elements, which are compulsory on bitrains, include the air suspension systems, Antilock Braking Systems-Electronic Braking Systems (ABS-EBS) and stability control, on-board weighing scales and a minimum weight/power ratio of 7.3Cv/ton, 70% higher than the requested for the other currently authorized heavy vehicles.

In 2017, the Ministry of Transport and Public Works (MTOPE) received a request from the private sector to extend to other corridors of the national road network the authorization to drive with bitrains, as well as to allow the circulation of other larger combinations such as:

1. the tritren, with three type B couplings, nine axles, 30m long and 74ton GVW, and
2. truck and trailer, with an A-type coupling, seven axles in total, 20m long and GVW 57ton.

To answer the industry request without compromising the safety of its inhabitants, the MTOPE engaged international consultants in a project to study the feasibility of the introduction of High Performance Vehicles with the objective to increase the productivity of the road transport fleet in Uruguay in a safe, cost effective and well-organized way. Experience in many parts of the world shows that the introduction High Performance Vehicles can be achieved with significant benefits such as increased road safety and reduced effects on the environment. The project aimed to use this experience to the benefit of Uruguay.

The four principles on which the feasibility study for the circulation of cargo transport vehicles with weights and dimensions higher than the current Uruguayan standards would be carried out on national roads were:

1. Promote progress in High Performance Vehicles (VAD, in Spanish)
2. Democratization of the use of HPV to other industries and corridors
3. Contribute to reduce the Uruguayan logistics cost
4. Care for safety and the environment

The project was divided in two phases. A first phase of two months, including a trip to Uruguay, to provide an initial report containing a basic diagnosis of the situation in relation to the existing regulation and infrastructure. Also, the report was to include an initial overview of the reasonableness of authorizing the circulation of vehicles requested by the private sector. The consultants would offer this overview based on their international experience, evidence-based international reports and the reconnaissance trip through various Uruguayan routes, which are detailed in the following section. Assuming the initial report was positive, a second phase would involve a 6-month thorough study including simulations of vehicle-infrastructure interaction and road trials of the proposed vehicles versus the conventional authorized ones.



**Figure 1 - Types of vehicles that consume 75% of equivalent axles, measured in weight stations (left), and type of authorised heavy vehicles in Uruguay (right)**

Neighboring countries to Uruguay have approved legislation regarding heavier and longer vehicles. Brazil, for example, has allowed nonconventional trucks to circulate since 2006. New regulations from 2016 allow 31m/90ton GVW bitrains, with no additional transport technology devices being required. In Argentina 25m /75ton bitrains have circulated in the province of San Luis for the past 10 years. A national decree allowing 30.25m/75ton bitrains, with compulsory technology similar to the Uruguayan regulation was signed in 2014 but only after four years and a new national decree trials started on national roads. Paraguay allowed Brazilian bitrains in 2018 through an experimental law, only to postpone its implementation for twelve months after two-week truckers' strike that brought the country to a halt.

The intention of this paper is to generate a discussion on ways of introduction and implementations of HPVs in different countries, from the experience of the feasibility study done in Uruguay. At the time the paper was written, the second phase of the project was about to start, with Terms of Reference for the second phase based on the positive report from the initial first phase. The authors expect to have results at the time of presentation in HVTT15 in October 2018. However, it is the way of introduction to the community that we find as interesting as the technical results themselves.

## 2. Literature Review

Longer and heavier vehicles are not necessarily more unsafe. Evidence-based international reports show that, in many cases, vehicle performance and road interaction are even better in heavier and longer vehicles than some of the vehicles circulating on roads, usually known as “conventional” (Glaeser & Ritzinger 2012), (National Truck Accident Research Centre 2017), (Fancher & Campbell 1994), (Steenkamp et al. 2017). In all reports, the best performance was achieved by those vehicles with B-couplings.

In 2011, the International Transport Forum of the Organization for Economic Co-operation and Development (OECD) published its report called *Moving Freight with Better Trucks*. For three years, a benchmark of 39 different combinations of heavy goods vehicles was carried out, from 10-member countries, on issues of productive performance, environmental, safety and driving dynamics, and impact on road infrastructure. Chapter 4 of the report specifically deals with the evaluation of benchmarking of the dynamic behavior of vehicles.

The results showed that misconceptions about longer and heavier vehicles have little scientific basis, and that in many cases these vehicles perform better in key areas than existing conventional vehicles.

The latest Australian report from the National Truck Accident Research Centre shows that the largest number of truck accidents reported were caused by inappropriate speed, where almost 70% of those accidents resulted in rollovers. (National Truck Accident Research Centre 2017) A similar result had been shown by its 2015 report, (National Truck Accident Research Centre 2015). High Performance Vehicles in Uruguay must be equipped with stability control in the prime mover and in all semitrailers and, as in Argentina, the prime mover is to be equipped with speed control (up to 90km/h, for example). Both elements combined could not only avoid those kind of accidents but increase road safety levels in Uruguay.

The overtaking maneuvers of vehicles on two-lane routes are inherently dangerous and stressful. According to evidence in international studies, for example (Ministerio de la Producción de Santa Fe, Argentina 2016), overtaking maneuvers on two-lane roads by high performance vehicles of 25m or 30m long do not present greater risks than those currently carried out on vehicles transporting machinery or cars of 22,40m. long. Moreover, due to its B coupling, which reduces rear lateral amplification and off-tracking, there is less risk of "touching" the vehicle which is overtaking than if that vehicle was overtaking a conventional truck and trailer vehicle. Note that having stability control devices on tractor and semi-trailers will help in the safe performance of Uruguayan HPVs with respect to the load transfer.ratio

### **3. Phase 1 of the Project: Consultants' Visit to Uruguay and Diagnostic Report**

On Sunday 29/10/2017 the consultants traveled in their private car from Colonia de Sacramento to Montevideo. On Monday, October 30 and Tuesday, October 31, they traveled together with MTOP technicians from Montevideo to Durazno and Tacuarembó. During the trip it was possible to appreciate traffic behavior, currently authorized freight vehicles and a special vehicle with larger dimensions. The URL <http://bit.ly/2zXbmfU> shows a Google-My-Map with pictures and videos from the trip.

Varying road heavy vehicles' dimensions is socio-politically complex, since the vehicles coexist with other subjects in the road network. For example, National Route 5 goes through the City of Durazno; side roads were specially built for safety, however we saw a lady on a bicycle, with headphones on, cycling next to a 45 ton old truck and trailer loaded with logs.

Most of the main national routes in Uruguay would permit modular HPVs, depending on the limitations in bridges and making minor geometric changes to the infrastructure -e.g. modification of some roundabouts and entrances in populated places, which would have to be specifically identified. Low speed off-tracking should be studied for the different units in this case.

Several of the secondary routes could be suitable for HPV circulation. Today, conventional vehicles with poor safety performance, such as trucks with trailers, circulate on several of these routes. Changes in the width of these routes, both in straight segments and curves, should be made for these vehicles, whose deviations at speed and rear amplifications are greater than those of the proposed HPVs.



**Figure 2 – An empty and a loaded forestry truck arriving at a crossing with a secondary road (left) and current traffic on that road. (Source author, 31/10/2017)**

Similar to Australia and San Luis in Argentina, Uruguay has a gently undulating geography. With a power/weight ratio of 7.3 HP as currently required for the Uruguayan bitrains, keeping the speed constant at the maximum required will not be an issue for high performance vehicles of greater weight and length. Technologies such as Hill Hold, Electronic Brake Assist (EBA) and Traction Control would also enhance safety on slopes, regardless of an increase in total weight.

Accompanied by mandatory safety and infrastructure care technology, HPVs could respond to the four principles enunciated by the MTOP. The mandatory technology of HPVs suggests that, in those routes where conventional trucks and trucks with trailers are currently traveling, HPVs can travel without inconvenience, in many cases more safely. Elements such as disc brakes, ABS/ EBS systems, stability control, higher power ratio that almost doubles that of conventional vehicles and type B coupling, air transfer for additional torque power, other mandatory devices will help HPVs performance regardless of road conditions.



**Figure 3 - A loaded forestry truck on National Road 5 waiting because of roadworks, (left) and current overtaking maneuvers on that road (right). (Source author, 31/10/2017)**

### 3.1 What was proposed for Phase 2

In order to respond to the four principles enunciated, and according to the experience and international evidence regarding the physical behavior of the requested vehicles, the authors suggested studying the tri-train (modular B-triple) and other intermediate configurations

between the current dimensions and the tri-train. It was suggested that the configurations to be studied will have all their elements (tractor and semi-trailers) coupled with B couplings. The option of the truck with trailer, with a type A joint, with seven axles in total, 20m long and GVW 57t would be totally excluded from the study.

The safety elements required would be equal to or greater than those required for the bitrains currently circulating in Uruguay. The vehicles would be studied for specific corridors, in loaded and empty conditions, which is when greater rear amplification can be experienced. The vehicles would be studied in a simulation process, and in real on-road conditions.

The HPV proposed to be studied were:

- bitrain of seven (7) axles, three (3) double axles and one (1) steering axle, of total length 22,40m and 57 ton GVW;
- bitrain of eight (8) axles, two (2) doubles, one (1) triple, and one (1) steering axle, of total length 25,50m and 64ton GVW;
- bitrain of nine (9) axles, two (2) triples, one (1) double, and one (1) steering axle, of total length between 30m to 30,30m and 71ton GVW; and
- tritrain of nine (9) axles, four (4) doubles and one (1) steering axle, of total length between 30m to 30,30m and 74ton GVW.

The reference vehicle would be a 20m 45ton truck and trailer. The MTOP added another vehicle combination to be tested, formed by one prime mover of three (3) axles and a semitrailer of triple axles, total length 18,60m and 48ton GVW, in sync with what the neighboring countries were allowing to circulate.

#### **4. Phase 2: Study for the Introduction of HPVs**

At the time of writing this paper, the second phase of the study had not begun. It is expected to have results of the second phase study for presenting them at the HVTT15 in October 2018. Therefore, this section will comment on the Terms of Reference provided by the MTOP with the aim of achieving a successful introduction of HPVs in the country.

The activities were divided in: firstly, physical aspects related with road heavy vehicles; secondly, infrastructure; thirdly, compliance, and fourthly, driver training. A team of regional and international professionals were gathered by the authors. Simulation studies will be performed by Woodrooffe Dynamics and the Australian Road Research Board.

##### **4.1 Regulatory framework of road heavy vehicles: weights, dimensions, and technical performance standards**

Initially the existing legislation will be reviewed and parameters not contained in the current regulatory framework in Uruguay, where international evidence shows positive impact for the increase of transport productivity, the improvement of road safety and the conservation of road infrastructure, will be identified. Substantial elements that should be part of the future regulation on weights and dimensions of HPVs, based on prescriptive limits on a set of physical parameters and performance standards, will be proposed.

Other parameters to be considered in the revised regulation of these vehicles through prescriptive limits, would be at a minimum:

- distance between axles and extreme axles,
- height of the center of gravity and lengths of the semi-trailers,
- front and rear overhangs,
- tire inflation pressure,
- other qualitative demands such as, for example; availability of ABS / EBS / ESP braking systems and a certain minimum value of the power/weight ratio.

Because safety performance of the mentioned types of vehicles does not depend exclusively on these parameters, the MTOP requested to work on the mandatory inclusion in the HPV regulations of the following performance standards:

1. Low speed turn, to report low speed swept path (LSSP) width, frontal swing (FS) and tail swing (TS)
2. Static rollover threshold (SRT)
3. Tracking ability on a straight path (TASP).
4. Startability/gradeability.

These standards will be simulated. All the simulations are to be executed with groups of axles in tandem and groups of three axes, with pneumatic suspension and a generic main engine. The speed limit for all vehicles will be 90 km/h, which is the maximum speed allowed, and for a speed of 110km/h, as part of a sensitivity study. The pertinence of including (or not) other PBS such as High Speed Transient Off-tracking (HSTO), Rearward amplification (RA), Yaw damping control (YDC) would have to be justified.

Field tests with prototypes of HPV will be undertaken as well. The objective of the tests is to verify the behavior of the different configurations in real traffic conditions. Therefore, they need to be carried out on representative routes with adequate conditions to perform some of the maneuvers, ensuring the safety of drivers and third parties.

The maneuvers to be executed in the field tests will include, at least:

- Overtaking distances
- braking performance
- tracking ability in a straight path (TASP)
- entrance to route junctions
- intersection clearance time
- 90 degree turns, at low speed, and
- slalom of cones.

#### **4.2 Aspects related with Road Infrastructure**

The methodological contributions for the aspects related with road infrastructure were divided between road geometry and structural design, and bridges structural design.

The national road network comprises 8,742 km and the departmental road network approximately 40 000 km, for a territory of 175 000 km<sup>2</sup> and a population of 3.2 million inhabitants. The national road network connects all the capital cities of the department with each other and with the two main ports: Montevideo and Nueva Palmira. Most of the routes of the national road network cross population centers that extend on both sides of the route, in many cases with typically urban cross-sectional designs. It is an almost entirely paved network

(4% are hydraulic concrete, 38% asphalt concrete, 50% bituminous treatment, only 8% granular material), although only the main hydraulic concrete network and most of the pavements in asphalt concrete have a modern geometric design.

Road geometry will be initially studied for longitudinal distances and lane widths necessary to carry out overtaking maneuvers of HPVs. Given the level of danger associated with these maneuvers, a current state of the art on the use of third paths of circulation, or other recommended measures on two-lane roads depending on geometric design of junctions and intersections, to allow safe entry opportunities to these extra-long vehicles, or the clearing of intersections, will be provided.

Forestry truck and trailers are common road users in Uruguay, as it can be seen in Figure 4, where six of them circulating at one instant, sharing the road with cars and pedestrians.



**Figure 4 – Intersections on the national road network. (Source author, 31/10/2017)**

The national road network has seven hundred and twenty (720) bridges, the vast majority being older structures. The condition of road bridges is a great concern for the authorities for authorizing HPVs, with their structural situation determining current restrictions to the circulation of vehicles with certain configurations of axes in some corridors.

The simulation study will provide a comparison between the simulations produced by the current authorized vehicles in relation to the ones generated by the HPV configurations described in 4.1. The MTOP also requested to research the pertinence of using a formula both for the control of the total gross weight as a function of the distance between extreme axles, in line with the table they have currently. The possibility of replacing current tables or formulas with alternative models, and criteria to be used in a transition stage will be reviewed.

### **4.3 Vehicle Compliance**

Tools will be proposed for the verification of the performance standards that will be mandatory during the period of use of the vehicles. A proposal containing adequate and practicable means of compliance and application to verify that the HPV comply with the approved operating conditions, including the description of the type, and periodicity, of the controls of the active, will be presented.

### **4.4 Driver Training**

A model of theoretical and practical training for drivers of HPV, including the training program and its duration, revalidation of certification, the use of simulators, the content of the practical part in particular the maneuvers to be evaluated in special enclosures and routes will be

proposed. International experience (Efron & Corvalan 2018) show that compulsory training, both on soft and hard skills, assists drivers who ultimately are the ones sharing the road with other road users, enhancing safety and promoting attitudes which promote public support of HPVs implementation and use.

### **5. Expected Results**

Four reports will be supplied, showing the status of the work. A First Progress Report after 3 months of the beginning of the study, in relation to a critical analysis of the national regulations on maximum weights of transport vehicles, road infrastructure, simulation of cabinet performance, and preparation of field tests. A Second Progress Report a month later, showing the final conclusions on the geometrical standards of the routes, and the progress of studies on bridges. Field tests will begin after the delivery of the second report. The Third Progress Report will present the final conclusions and recommendations on bridges, cabinet simulations and field tests, as well as progress on approval protocols and verification of compliance with the technical requirements of the HPVs, and a Final Report will be presented at the end of the sixth month including proposals on driver training, and the basis for the formulation of a "hybrid" regulation on maximum weights for cargo transport vehicles which include HPVs.

### **6. Discussion**

The intention of the paper is to generate a discussion on ways of introduction and implementation of HPVs. The authors have found that countries, although different in many ways, have similar cultural attitudes and myths to the use of HPVs. Diverse implementation strategies were discussed by (Efron & Corvalan 2016) in their paper for HVTT14 *From paper to road- and back again: a comparison of the implementation of high capacity vehicles in Latin American countries*. Successes, failures and current status of the implementation strategies were described in that paper, showing that the implementation of new heavy vehicle technologies could be influenced by the different stakeholders' agendas, regardless of physical technological evidence.

Uruguay has decided to engage in a thorough feasibility study to review all its heavy vehicle legislation, a challenge which will take almost a year and the hiring of international renowned consultants. The authors think it is a good example that could see HPVs being implemented in a structured and sustainable manner, hope to discuss the study results at HVTT15 and welcome any comments.

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