

Truck Silhouettes Analysis with WIM Data

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ISWIM - Pretoria

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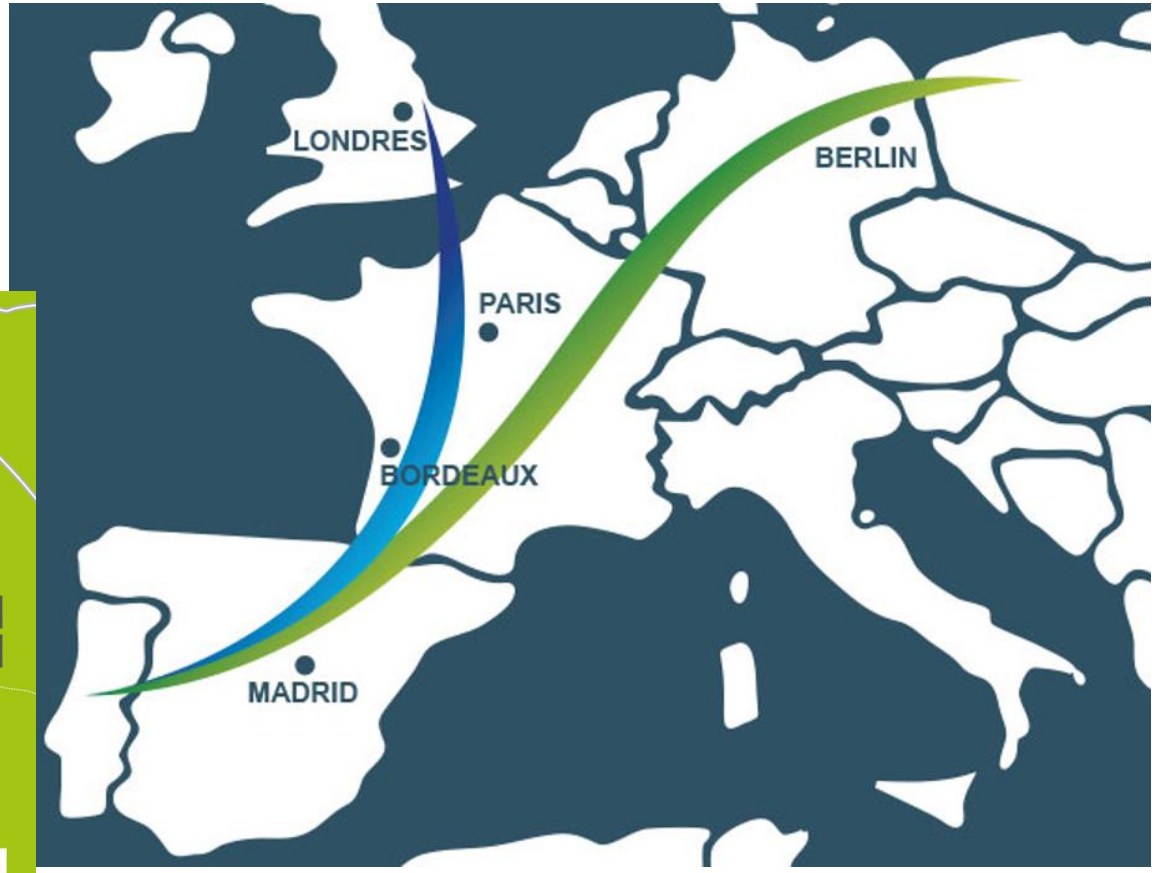
A63 - Atlandes

- A63 motorway is a strategic link for Europe



AADT 9500 trucks/day

Peak ADT 14000 trucks/day

2 WIM stations (1 by direction) right lane only

WIM data for enforcement

- To be efficient to enforce weight regulations, any system needs to:
  - 1 - Weight the vehicle with sufficient accuracy
  - 2 - Determine what is the weight limit for the vehicle
- For automatic devices, the easiest part might not be the second one…
- In France (and Europe) vehicle weight limits are closely linked to the number of axles and more precisely to the truck “silhouette”, but can also depends on the nature of trips (40t only for crossborder vs 44t for domestic…)
- In Intelligent Access Programs, this can be solved by V2I communication…
- … But silhouette analysis and classification remains the basis to assess authorized weight limitation in many cases

WIM data: focussing on truck silhouette

- Truck silhouette relies on axles detection and eventually on photo analysis
- Let's focus on axles detection only (no camera needed / low data volume): the truck will be described as distances:
  - Head: distance from "head" (bumper) to 1st axle
  - D2 to DN: distance between axle 1 and 2 to distance between axle N-1 and N
  - Tail: distance from axle N to rear
  - Sum = total length

- Each silhouette is a tuple of N+1 values, N being the number of axles
- Analysing these values intends to help identifying truck

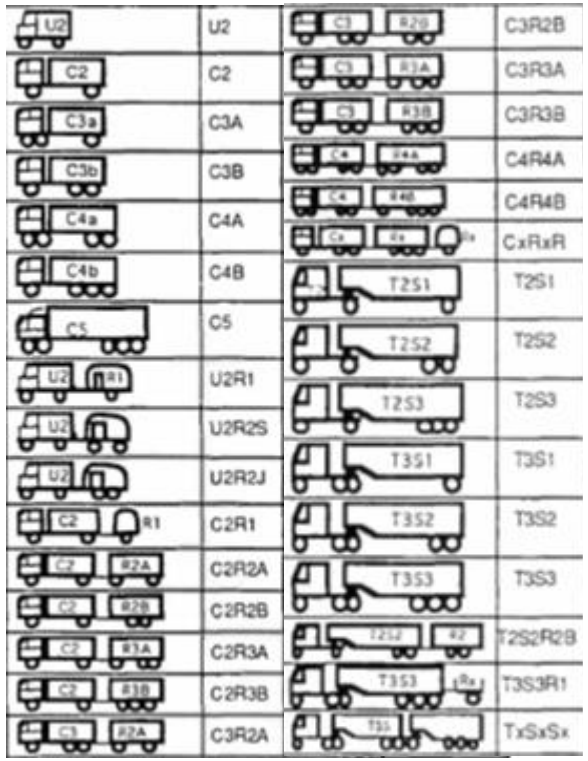
A63 main issues

- Most incidents concerning trucks occurring on A63 are flat tyres (61%), mainly due to tyres wear and tear but in some cases to overloads;
- To reduce tyres wear and tear, and therefore maintenance cost, but also marginally fuel consumption, most trailers have lifting axles. This enables driver to lift an axle from the road when running empty or partially loaded.
  - Detecting silhouette with lifted axle can therefore be interesting

- A63 is used by overweight trucks for wood transport (up to 48t on 5 axles and 57t on 6 axles and more)
  - Detecting those trucks is important to enforce normal weight limit (40/44t)

A63 WIM Data analysis: general methodology

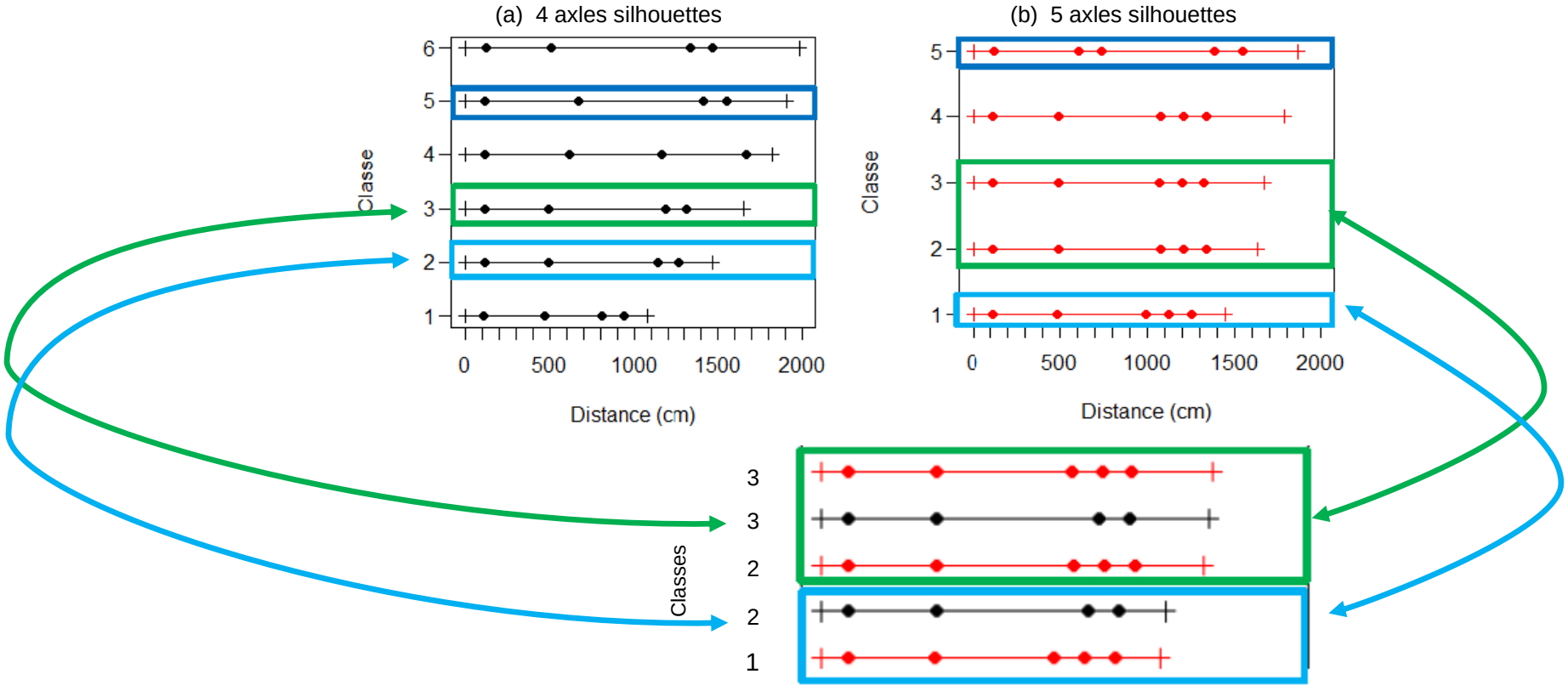
- A national classification exists, as shown right, wich serves as a reference
- To go further, a statistical classification method that groups together vehicles with similar silhouettes was used on A63 data
- analysis was entrusted to the Société de Calcul Mathématique (SCM) who used the non-hierarchical classification method for mobile centers (k-means)
- 5 to 6 classes were chosen for each axle number group, for 3 to 8 axles trucks



A63 WIM Data analysis: methodology: closeup on lifted axles

- The aim is to reconstruct the silhouette of certain trucks, notably semi-trailers known as T2S2 or T2S3 in the national classification for a 2 axle trailer with a semi-trailer with 2 or 3 axles (tandem or tridem), including the case where one axle is lifted;
- Using the classification to identify vehicles with one or more lifted axles is based on the comparison between geometrically similar silhouettes but with different numbers of axles

A63 WIM Data analysis: outcome for semi-trailers with lifted axle



Most likely Lifted axles

comparing silhouettes with 4 and 5 axles: 4 axles trucks divided by the method into 6 classes (fig a) and 5 axles truck into 5 classes (fig b). Silhouettes shown in the graphes describes the centers of those classes, defined by relative axle positions. Below is shown the classes from 4 and 5 axles silhouettes that can be grouped because of their similarities. Classes 3 of the 4 axles group matches quite well with classes 2 and 3 of the 5 axles group.
The same applies to classes 2 and 1 of vehicles with 4 and 5 axles respectively.

A63 WIM Data analysis: checks

- To ensure that heavy goods vehicles in the T2S2 categories without a lifted axle were not assimilated to T2S3 with a lifted axle, total weights were analysed
- Statistical classes are those presented in previous slide from which T2S2 represents more than 80% of data. Among those T2S2 classified, those from class 6 are true (native) T2S2 with no lifted axle, accounting for a bit more than 15% of the sample.

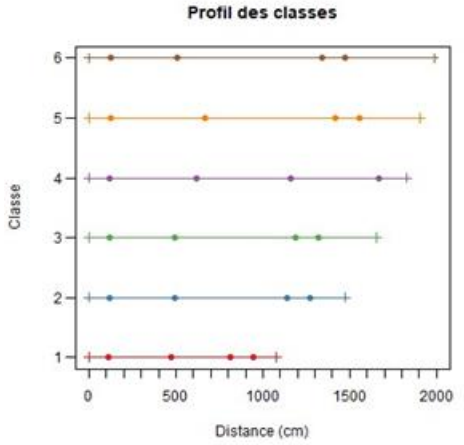
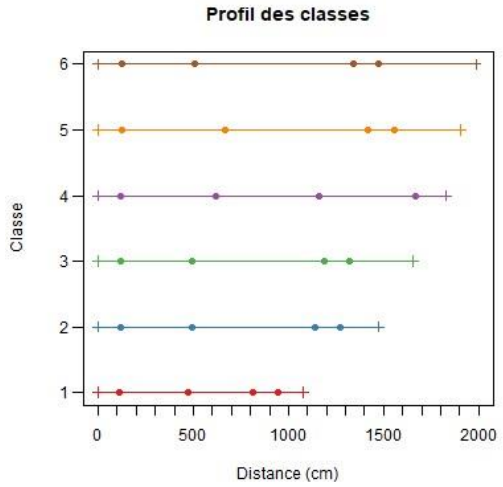
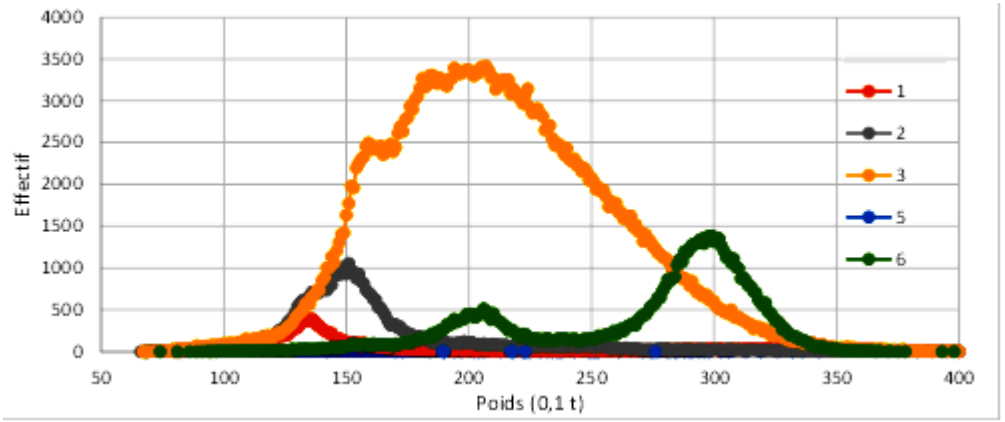


TABLE 1 : T2S2 classification							
Classes	1	2	3	4	5	6	unclassed
Share	2,82%	8,65%	72,88%	0%	0%	15,40%	0,26%

A63 WIM Data analysis: checks





Total weight distribution for 4 axles classed trucks

From the distribution of total weights in each class 1 to 6 for T2S2 we observe:

- Class 1, shortly populated, gather short vehicles (approx. 11m) and empty, with a mode close to 13t;
- Class 2, with a unique mode around 15t, includes short T2S3 (around 14,5m) with third axle lifted. It probably describes dump trucks or car transporter trucks running empty;
- Class 3, the most populated, includes standards T2S3 (16,5m) mainly “curtainsider semi-trailers, with third axle lifted, empty or partly loaded, with a mode around 20t and a widespread distribution;
- Class 6 corresponds to “true” T2S2, trailer and semi-trailers with 4 axles, with two modes around 20t and 30t corresponding to empty and loaded vehicles; we find here curtainsiders again and car transporters (fig 8), and
- At last, classes 4 and 5 do not correspond to T2S2 but rather to truck and trailer vehicles, categorized as C2R2 (A or B) in France, and therefore not present in the sample (0% for each classes).

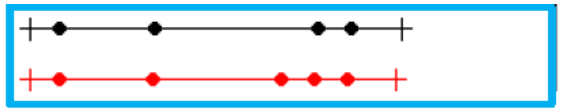
A63 WIM Data analysis: checks

- But still...

We might still have T2S2 class 3 or 2 that are « true » trailers with 2 axles only… how could we eliminate them ?

A63 WIM Data analysis: in depth analysis

- To improve confidence in lifted axle identification, we measure the “distance” between the truck silhouette and the T2S3 statistical class corresponding silhouette

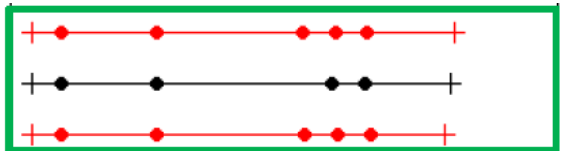


1st case T2S3 class 1 <> T2S2 class 2 (short semi-trailer)

T2S2 class 2 : individual truck data (H,D2,D3,D4,T)

T2S3 class 1 : mean data (Hm,D2m,D3m,D4m,D5m,Tm) <> for the 3rd axle lifted (Hm,D2m,(D3m+D4m),D5m,Tm)

Distance = $\sqrt{(H-Hm)^2+(D2-D2m)^2+(D3-(D3m+D4m))^2+(D4-D5m)^2+(T-Tm)^2}$

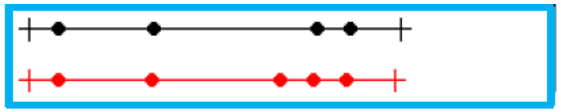


2nd case T2S3 class 2&3 <> T2S2 class 3 (long semi-trailer)

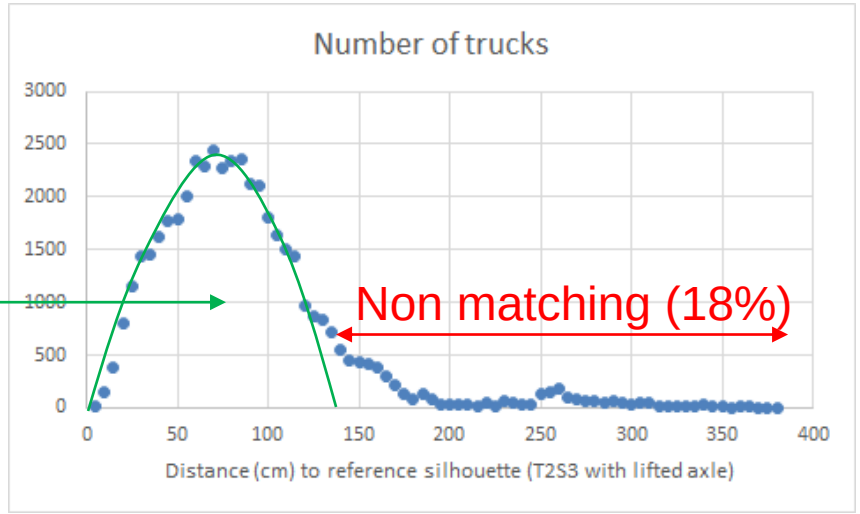
A63 WIM Data analysis: in depth analysis outcome

- Distance distribution for the two cases

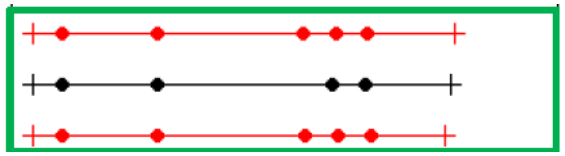
1st case T2S3 class 1 <> T2S2 class 2 (short semi-trailer)

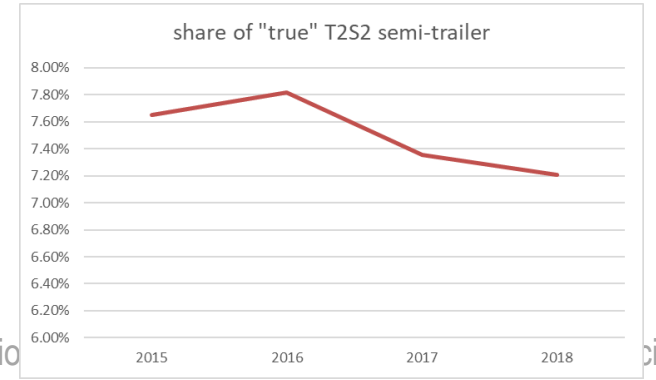


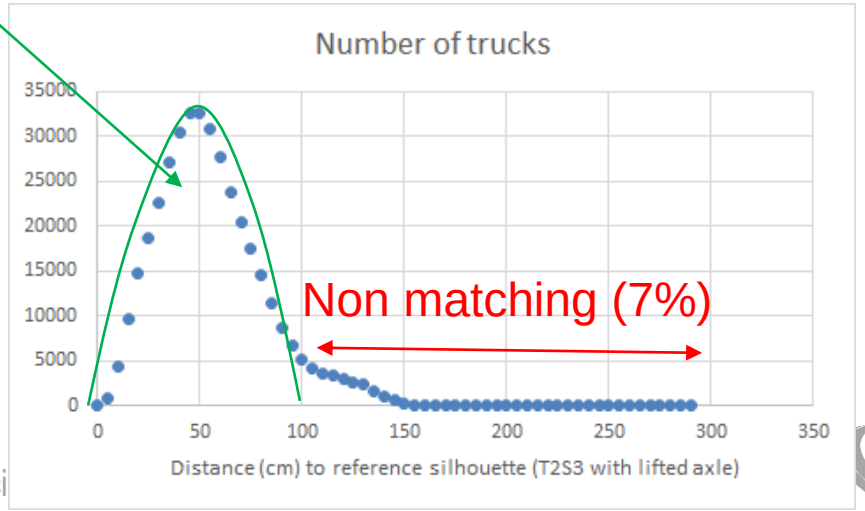
Matching silhouettes



2nd case T2S3 class 2&3 <> T2S2 class 3 (long semi-trailer)
(with final distance = minimum of the 2 distances)







A63 WIM Data is worth analysing !

- Finally, the various steps show that with only basic data as axles distances, we can have a good identification of truck silhouette
- This can be used to identify semi trailers running with lifted axles
- Further analysis on silhouette can help determine the applicable weight limit and therefore enhance enforcement efficiency

Thank you for your attention!

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