

A New Approach of Smart Mobility for Heavy Goods Vehicles in Casablanca

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Abstract. Managing mobility, both of people and goods, in cities is a thorny issue. The travel needs of urban populations are increasing and put pressure on transport infrastructure. The Moroccan cities are no exception and will struggle, in the short term, to respond to the challenges of the acceleration of the phenomenon of urbanization and the increase in demand for mobility. This will inevitably prevent them from turning into smart cities. The term smart certainly alludes to better use of technologies, but smart mobility is also defined as “a set of coordinated actions intended to improve the efficiency, effectiveness and environmental sustainability of cities” [1]. The term mobility highlights the preponderance of humans over infrastructure and vehicles. Faced with traffic congestion, the solutions currently adopted which consist of fitting out and widening the infrastructures, only encourage more trips and report the problem with more critical consequences. It is true that beyond a certain density of traffic, even Intelligent Transport Systems (ITS) are not useful. The concept of dynamic lane management or Advanced Traffic Management (ATM) opens up new perspectives. Its objective is to manage and optimize road traffic in a variable manner, in space and in time. This article is a summary of the development of a road infrastructure dedicated to Heavy Goods Vehicles (HGV), the first of its kind in Morocco. It aims to avoid the discomfort caused by trucks in the urban road network of the city of Casablanca. This research work is an opportunity to reflect on the introduction of ITS and ATM to ensure optimal use of existing infrastructure before embarking on heavy and irreversible infrastructure projects.

Keywords: smart mobility, intelligent transport systems, advanced traffic management, heavy goods vehicles.

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1. Introduction

In Casablanca, the traffic problem is one of the major challenges that it must win, whether decision makers choose the solution of the smart city or not. An efficiency gain in terms of circulation and mobility could lead to significant savings. But what seems obvious now is that conventional traffic management would not make it possible to absorb sustainably the consequences of congestion during peak hours. Traffic congestion will inevitably lead to a deterioration of the urban framework and road safety conditions and will hurt the city's competitiveness. The intensification of HGV flows from or towards the port on the Casablanca routes accentuates congestion, causes roadway degradation, worsens various nuisances, and pollution (noise, air, visual). Moreover, it contributes to the consumption of public spaces and assistance in the mortality of users of alternative modes. At the same time, the existence of industrial and commercial blocks in the city center, backed by storage functions, generates a high demand for transport and parking. Based on this fact, the deviation of HGV flows from the city center involves a major urban challenge. The optimization of logistics for the delivery of goods has vital importance for the competitiveness and attractiveness of the city, improvement of the quality of life, accessibility and road safety. The case of the separation of the urban traffic and the HGV traffic circulating between Casablanca port and Zenata dry port is a relevant example where smart mobility could provide efficient solutions allowing to avoid building costly tunnels.

2. Literature Review

In 2014, the National Sustainable Development Strategy 2030 (SNDD 2030) of Morocco identified the transport sector as the third energy consumer in Morocco. It accounts for 16% of total emissions and 28% of emissions from energy. Morocco was among the first countries to have embarked on the Mobilize Your City (MYC) initiative during the COP22 in Marrakech in 2016 [2]. Sustainable mobility is defined as “a transport policy which seeks to reconcile accessibility, economic progress, and the reduction of the environmental impacts of the selected transport systems” [3]. The transport of goods is also concerned with ambitions to optimise existing networks and improve nearby exchange platforms, allowing efficient transfers between different modes of transport. Morocco is the first country to have initiated an adaptation of the global macro-roadmap for the transformation of transport based on the Paris Process on Mobility and Climate (PPMC). The Moroccan Roadmap of 2018 recommends the creation of vertically and horizontally integrated, sustainable industrial zones close to consumption and connected to mass transportation modes. Defragmented and shortened supply chains reduce the need for transport and eliminate unnecessary trips. Over the past decade, Morocco has seen significant progress and reforms in the areas of the environment, sustainable development, and the fight against climate change. Several sectoral strategies, including transport and logistics, integrate these environmental dimensions. The economic stakes are high as the cost of air pollution in Morocco accounts for more than 10 Md DH (1% of GDP) [4].

Morocco is implementing an integrated national strategy for the development of the logistics sector by 2030 with clear and quantified macro-economic, urban, and environmental objectives. Since sustainable development is at the heart of this strategy, its objectives contribute to a reduction of around 35% in CO₂ emissions resulting from the transport of goods by road [5]. To achieve these objectives, pooling flows of goods

has been considered as a primary solution. The creation of 3000 ha of logistics platforms by 2030 is among the main levers for reducing delivery costs and the carbon footprint of the import/export supply chain, thereby improving the quality of life, accessibility, and competitiveness of urban communities [6]. In 2019, Casablanca was selected by the Institute of Electrical and Electronics Engineers (IEEE), to be part of the IEEE Smart Cities Initiative. The city was recognised for innovative projects aimed at the transformation to a smart city and intentions to invest in the human and financial capital of the city. Aiming to tackle economic, urban, and environmental challenges the Casablanca's Urban Mobility Plan (UMP) considered the following trend scenario [7]: the energy consumption: MAD 4.2 billion (2004) compared to MAD 9 billion in 2019, the cost of congestion: MAD 114 million in 2004 against MAD 3.4 billion in 2019, the cost of pollution: MAD 319 million in 2004 against MAD 1 billion in 2019. To address these challenges, the priority actions recommended in the Casablanca's UMP include the creation of logistics lanes for HGV.

3. Research methods

The average annual daily traffic of the road circulating between the port of Casablanca Multi-Flow Logistics Zone (MFLZ) of Zenata, resulting from an automatic count established by a permanent post, is 21000 vehicles [8]. A metering campaign made it possible to quantitatively and qualitatively a load of directional traffic at crossroads and in the section during rush hour. The maximum Peak Hourly (HP) traffic in a section is around 3300 Vehicles in both directions, 10% of which are HGV of 13 m. The strongest hypothesis of the National Ports Agency (ANP) considers that 100% of container HGV (3200) and 100% of non-container HGV from port activity (5600) will pass through the northern service in both directions by day. The dimensioning HP traffic is 1100 HGV (36% of HGV of 13 m and 64% HGV of 17 m) [9]. To quantify the impact of the proposed lane dedicated to HGV in Crossroads, dynamic simulation is carried out by Aimsun software. This simulation makes it possible to visualize the circulation of vehicles and pedestrian crossings. The generation of vehicle traffic on the main road and on the secondary roads was carried out by taking the above traffic data. Several replications were launched to obtain an average of over one hour. Each replication generates traffic randomly over time while respecting the Origin/Destination matrix. Thus, each replication has variations in traffic making it possible to observe different traffic conditions (local congestion, repetitive calls on secondary axes, absence of pedestrian calls).

4. Research results

4.1. Analysis and proposal for the development of a lane reserved for HGV

Six variants can be considered. They are presented as follows:

- Variant 1: Road in 2x3 lanes: mixed traffic between HGV and urban traffic.
- Variant 2: Dedicated corridor for HGV: partial separation of traffic.
 - Sub Variant 2.1: Dedicated central corridor for HGV in 2x2 lanes.
 - Sub Variant 2.2: Dedicated central corridor for HGV in 2x1 lanes.
 - Sub Variant 2.3: Dedicated side corridor for HGV in 2x1 lanes).
 - Sub Variant 2.4: Two dedicated bilateral lanes for HGV.

- Variant 3: Dedicated corridor for HGV in 2x2 lanes and uneven junctions: total separation of traffic.

The chosen variant must meet the following requirements:

- An optimized impact on the expropriation and the networks;
- Design compatible with the adjacent cornice project from an urban point;
- Fluidity and protection of pedestrians heading towards the beach;
- Capacity on the current section of lanes reserved for HGV;
- Maintained operation in the event of accidents in the lanes reserved for HGV;
- Secure traffic at intersections;
- Travel time promoting the competitiveness of the logistics area;
- Fluidity of vehicles and improvement of capacity on highways;
- Fluid and unrestricted management of traffic during the works;
- Limited equipment maintenance;
- Respect the cost allocated to the project.

The sub-variant 2.2 is the only one to meet the above requirements. Its feasibility was subsequently studied. The Cross-Type Profile (see Fig. 1) of this variant is as follows:

- 2x2 lanes of urban traffic at the lateral level + 3rd Turn Left lane;
- Central corridor dedicated to HGVs in 2x1 lanes 9m wide;
- Separation between the two corridors;
- Support measures in terms of detection and traffic management.

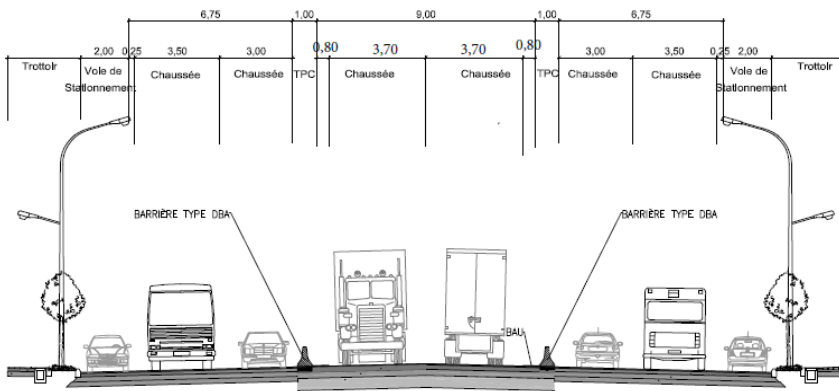


Fig. 1. Cross-Type Profile recommended of sub variant 2.2.

4.2. Checking the feasibility of a planned HGV lane

The figures 2, 3 & 4 show that the proposition of the 9 m width for the two bidirectional lanes dedicated to HGV means the operation in a degraded mode in the event of a truck failure on the lane. Measures can be used in the event of a truck breakdown, such as movable double concrete partitions used to clear HGV through side lanes in the event of a serious accident in the HGV lane.

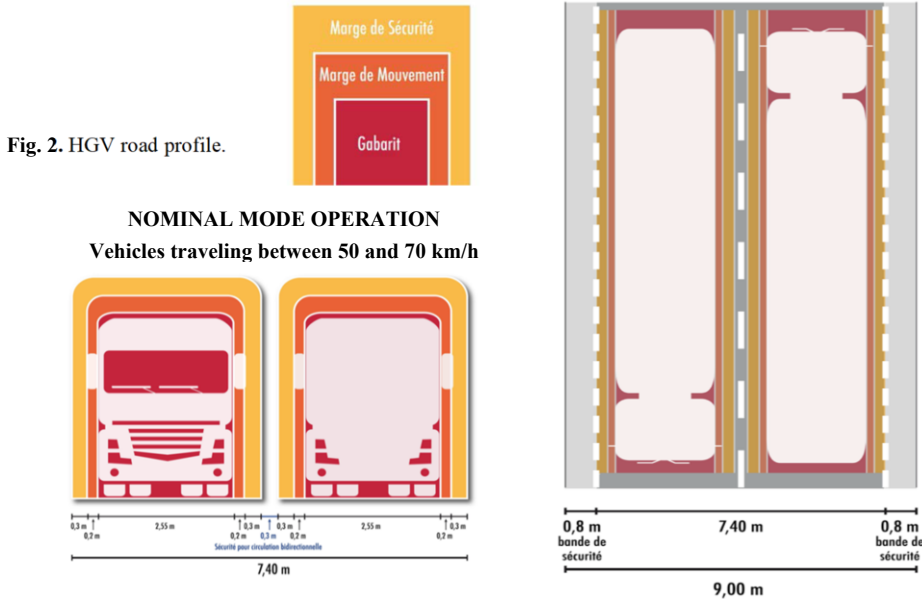


Fig. 3. Checking the gauge of dedicated traffic lanes for HGV in nominal mode operation.

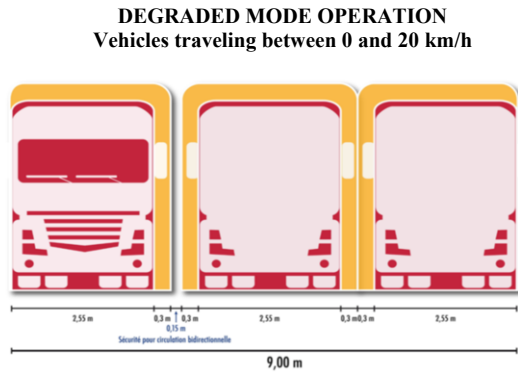


Fig. 4. Checking the gauge of dedicated traffic lanes for HGV in degraded mode operation.

The crossroads. The traffic light intersections are programmed as follows:

- Cycle time of 80 seconds;
- Keeping the main axis green (at least 45 seconds of green to clear the 550 HGV/h per direction);
- Turn left and secondary axes phases on-call (8 seconds of green per phase).

Sensors are placed on the turn left way and on the secondary axes to detect the presence of the car to leave the rest point of the main phase.

The Aimsun software has a "yellow box" function for traffic intersections. When this function is activated on the crossroads, vehicles do not enter if there is a risk of lifts and blocking. Vehicles wait at the light line until the intersection empties. To reproduce the effect of "yellow box", a system of saturation loop and early closing of the light lines is to be expected. (see Fig. 5)

Pedestrians at the crossroads are served during Turn a left phases and secondary axes.

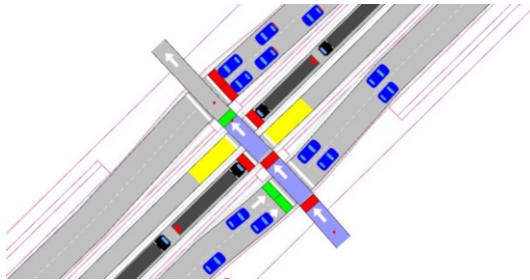


Pedestrians on secondary axes are served during the main phase. Pedestrian detection devices will be used for these crossings to reduce the waiting time for pedestrians by contracting "green cars" if no vehicles are approaching the crossroads.

Fig. 5. Crossroads in "Don't block the box" mode.

Pedestrian crossings in section. To manage pedestrian crossings, a dedicated facility will be created for pedestrian traffic. When a pedestrian is detected, a call is made and the car/HGV phase turns red after 29 seconds so as not to constrain the flow of vehicles. The operation of pedestrian crossings on call does not create a green car wave on the whole road. To optimize the operation of pedestrian crossings transversely, each pedestrian signal opens in the offset to limit the times of red vehicle/HGV.

A "yellow box" is placed downstream of the pedestrian crossing (see Fig. 6). This function is activated in order not to have a vehicle/HGV blocked on the pedestrian crossing.



Trucks do not cross the pedestrian crossing if there is insufficient space for its storage. The blue areas on the pedestrian path are detectors that activate the pedestrian green when it detects a presence.

Fig. 6. Pedestrian crossings in "Don't block the box" mode.

5. Discussion of the results

5.1. Simulation analysis

HGV's traffic on a dedicated central site. All HGV, in simulation, arrive at their destination without too much waiting due to congestion. The average journey time is 12 min over the entire section. Their total downtime is 3min and 40sec. They, therefore, have an average speed of 25 km/h (see Fig. 7).

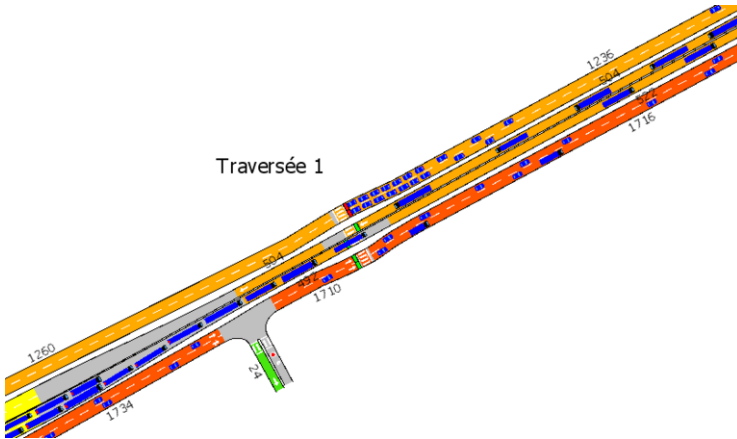


Fig. 7. Calculation and verification of hourly flow rates in lateral tracks and dedicated lanes.

Vehicle’s traffic on the sideways.

The crossroads with lights being dimensioned to smooth the more important circulation of Heavy Goods Vehicles in the dedicated site (1475 vehicle/lane/direction/hour), the vehicles (825 vehicle/lane/direction/hour) profit from the same times of green HGV. Then, no problem with raising the queue.

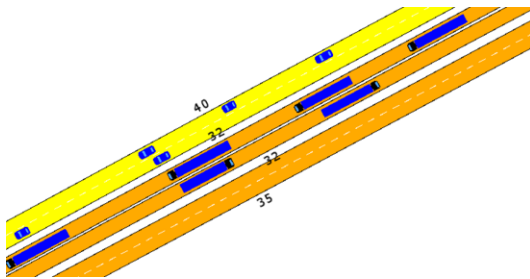


Fig. 8. Average speeds in the lateral way and the PL tracks.

The cars cover the 5km in 9min which gives an average speed of 32 km/h (see Fig. 8). Vehicles coming from the secondary axis of an intersection regularly pass to the second cycle. This intersection as a resting point on the main one operates cyclically due to the permanent calls from the secondary axis. Vehicles wait an average of 75 seconds to pass the line of lights (green time being 10 seconds).

Fluidity of pedestrians. The 15 pedestrian crossings in the section are managed to call. Pedestrian is served 29 seconds after its detection to leave a minimum green time for HGV in a dedicated site. On average, a pedestrian takes 54 seconds to cross the entire road (including detection time) with an average speed of 5 km/h.

5.2. Criteria of Intelligent Transport Systems (ITS)

To ensure the optimal simulated operation at the Aimsun Software level, the equipment of the vehicle and pedestrian detection system and ATM must constitute an intelligent transport system and have the following functions and characteristics:

Diagram of the overall functioning of the ATM System. The Diagram below summarizes the overall operation of the integrated traffic operating system allowing ATM with prioritization of HGV flow, detection and securing of pedestrian crossings, intelligent management of traffic lights, information for users at through Variable Message Panels (VMP) and data acquisition and monitoring by WEB. (see Fig. 9)

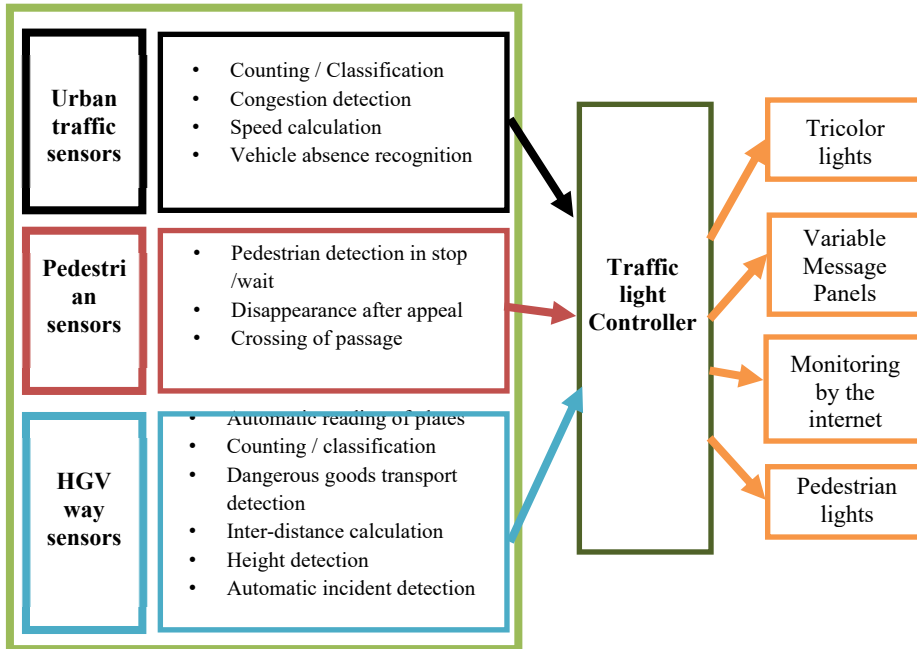


Fig. 9. The overall functioning of the Advanced Traffic Management system.

The adaptive and intelligent traffic light controller. It is an automat dedicated to adaptive management and intelligent regulation of road traffic without necessary a central control having as specific characteristics:

- A history of traffic data, analysis, optimization and evaluation of the effectiveness of the dynamic control system, visualization by the website;
- Recognition of the absence of a vehicle at the intersection to avoid giving unnecessary priority;
- Processing of information from various traffic detectors;
- Compatibility with DIASER and OCIT 2.0 communication protocols;
- Equipped with SIL3 (Safety Integrity Level): redundancy of controls;
- Complies with the requirements of standards EN12675 and EN50556;
- Programmable with third-party software LISA + and VS-PLUS;
- Capable of controlling traffic lights in different voltages (230VAC/110VAC) with bulbs or LEDs, 40VAC for LEDs, 24VDC;
- Possibility of attenuation mode at nightfall with 42VAC dimming module;
- Possibility of policy manual control;
- Priority configuration for firefighters / police / emergencies;

Thermal detection system. It's a thermal imaging camera of vehicles and pedestrians with the following characteristics:

- Detection of saturation of lanes;
- Automatic Incident Detection (AID) on the HGV track for deviation through cross-arrow tanks;
- Detection of pedestrians crossing;
- Dynamic micro-regulation of tricolor lights cycles time;
- Don't block the box flow and saturation control;
- Vehicle counting and classification;
- Over-height detection;
- Reading of Dangerous Goods Transport (DGT) plates;
- Calculation of the speed of the HGV through virtual loops (If $V > V_{max}$: the light turns red);
- Automatic Reading of License Plates (ARLP) by day and by night;
- All-in-one sensor (infrared and CMOS "very high sensitivity");
- 24/7 detection in various weather conditions;
- IP connectivity and configuration via secure Wi-Fi / 3G connection;
- 8 vehicles or pedestrian presence zones;
- Video stream visible in HD (Protocol and RTSP image stream);
- A countdown of the waiting time before going green;
- Management of Variable Message Panels (VMP) and cross-arrow trays.

Polycarbonate signal lanterns: must have the following characteristics:

- Anti-vandalism, slim design, blending in historic urban areas;
- Can be mounted vertically or horizontally;
- Available in \varnothing 100/210/300 mm.

LED modules: must have the following characteristics:

- No visible LED point - central light source;
- Higher anti-ghost performance (class 5);
- Lower energy consumption and brilliant light output;
- Custom masks that can display any symbol;
- Optimized thermal concept, reducing degradation to a minimum;
- Automatic light compensation in case of diode failure;
- Degraded mode functions available in 42V;
- Compliant with DIN VDE 0832 standard.

Pedestrian push button: must have the following characteristics:

- Modular construction allowing adaptation to all types of intersections;
- No moving parts which could be deactivated with toothpicks, gums;
- Laterally tactile symbols appeal to describe the passage for the visually impaired, integrated acoustic units;
- Location of the push button, thanks to the acoustic and optical position signal;
- Meet all the requirements of the directives and regulations in force (RILSA, DIN 32981, DIN VDE 0832, EN 50293).

Environmental sensor: should allow the following measurements:

- Measurement of gases (NO₂, O₃, CO, CO₂, VOC);
- Measurement of polluting fine particles (PM₁, PM_{2.5}, PM₁₀);

- Measurement of noise, humidity, temperature, and pressure;

Weighing at the current speed. Weighing-in-motion systems with dynamic weighing sensors help quickly pick up vehicle and axle weights for safer roads and better traffic management.

Conclusion

The installation of 15 secure pedestrian crossings throughout the 5 km of the project in addition to a pedestrian crossing on each of the 5 main intersections has made it possible to reduce HGV speeds, to manage traffic in packages, and to ensure maximum protection of pedestrians. Besides, with the help of ITS, several issues related to traffic regulation and fluidity have been resolved. The dynamic and adaptive management of traffic lights has therefore made it possible to reduce ways dedicated to HGV while minimizing journey time. The use of ITS will allow the registration of traffic data, the collection of information about special events, and the management of system efficiency for real-time. Innovations and intelligent systems deployed which made it possible to bypass the HGV of downtown Casablanca with a significant gain in terms of competitiveness for businesses will have a significant positive impact, also, on the quality of life of citizens and on the city environment. Finally, this research led to the design of a new approach of smart mobility for HGV with introduction of ITS to ensure the optimal use of urban roads in Casablanca.

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