Towards a traffic management in expressways to increase resilience of urban logistics in Metropolitan Lima and Callao

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***Abstract*– This research tackle about how increase the resilience of urban logistic through traffic management in Metropolitan Lima and Callao, on expressways. It is proposed a roadmap of four steps to accomplish this propose are: (i) first do a literature review about optimization and simulation previous experiences and database about current state urban logistics. Second, determine a qualitative and quantitative traffic system management, designing scenarios that predict traffic and its state variables considering their relationship. Third, an optimization and simulation model that assessment resilience level, a calibration database protocol will valid the resilience model. Fourth, a final resilience system model of traffic management to be tested to simulate different flows users on city road network.**

Keywords - Traffic management, expressways, resilience.

I. INTRODUCTION

Lima is a city with problems to be manage such as climate change, scarcity of water, seismic activity, high rate of unemployment, widespread insecurity, and urban vulnerability. Enabler as vehicular congestion, old automotive offer and others; makes necessary the city increase their resilience in face disruptive events; In Peru, from 1582 to 2007, occurred 47 earthquakes with magnitudes between 6.0◦ to 8.6◦ on the Richter scale. At least ten were greater than 8.0◦, and 100% of them took place around Lima and Callao area. Reference [10], state in relation to urban transport it is necessary to provide an optimal, efficient and resilient route design regarding the constraints of a post-sudden disruptive (e.g. disasters) environment.

The collection of data in several points of a city presents financial limitations and even more so when the city has an unplanned growth at the population and land use level (for example, Lima and other cities with similar characteristics). A study of its road characteristics in a segmented way with simulation and prediction algorithms is an alternative for economic and reliable decision, which is also a tool that would help to understand the behavior of the road system and improve the application of planning measures, which contributes to the improvement of urban logistics.

The essential services of the city of Lima remain in the center of the city and in the financial center (such as work centers, study centers, service offices and others) And the main arteries of urban vehicular transport through which the people are gradually saturated. The average speed of traffic has decreased, creating several bottlenecks and other problems of traffic congestion, which increases the waiting time and permanence of a vehicle in a Road System (i.e. a set of routes that are necessary to move from one place to another). According to the update of the Master Plan of Lima carried out by JICA [4], the speed in the peak hours of morning and night in the main avenues of the city is less than 20 km/h. In this plan, the destination-origin matrix is elaborated for road planning; all of the above indicates that it is necessary to study how the operation of an expressway is related and the traffic state variables of the adjacent road network.

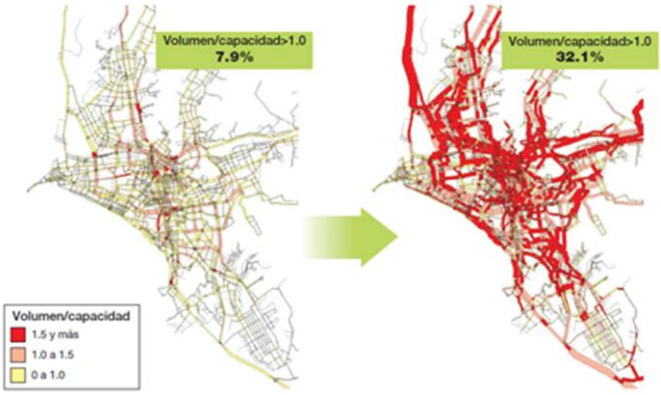

Figure 1. Vías de red vial con relación Volume/Capaciity greater than one - saturated- to 2004 and to 2025 [3].

In [9], It is described methodologies to make risk models of urban freight transport, which include stochastic programming, multi-objective, optimization, multi-agent simulation and traffic simulation. Within the concept of resilient cities in [5], the authors focus on transport infrastructure vulnerability. Traffic variables are not measured at all points of the road system mainly due to technology and financial limitations [8], these are important because from them are decided extensions or modifications of the urban road infrastructure (Lima or another city with similar characteristics). These extensions or modifications must contribute to the resilience of the system, that is to say, an effective measure must be conceived from the logistical improvement of the system in which it is implanted, all the

above with a suitable numerical tool, allows to infer with precision the state of traffic variables, which leads to better decision proposals in terms of managing the flow of people, vehicles, infrastructure, travel desires, regulation of traffic attracting centers, so that the interaction of these factors increases the recovery capacity of the city in adverse scenarios.

A study published in 2017 [7], on new trends in simulation of real-time traffic indicates that these are suitable for heterogeneous media; in [7], the efficiency of many simulation programs is compared; reference [11], indicates that intelligent transport models ITS, such as Integrated Self-Regressive Average Model ARIMA, and similar ones used in the prediction of flow, require a considerable database, as an alternative to this problem it proposes the use of the filter of Kalman KFT, to be applicable to databases of smaller size.

II. THEORETICAL FRAMEWORK

The study is important because it increases the knowledge referred to the improvement of the urban logistics, using expressways as an element that increases the resilience in a city. The knowledge referred to the prediction of the behavior of the traffic in expressways is also increased, with the inclusion of new numerical models that relate the variables of state of traffic and the concept of resilient city; The potential beneficiary of this study will be the population in general and the entities in charge of traffic management.

A road network is represented by a network of bidirectional graphs, where each graph is assigned a numerical value according to its importance. The variables of the state of the vehicular flow that affect the traffic and the congestion are: intensity, speed, density of traffic, nevertheless its relationship with the road capacity, is important.

The capacity of recovery of a city in front of a crisis is called resilience. The study of it in urban roads that improve the behavior of a city is important, because a city like Lima, for example, needs a continuous improvement of its resilient capacities, to deal with inherent risks presented by the seismic. The amount of population it has and the movement of disorderly flows, the latter mainly because its poor management reduces the standard of living of a city and makes its connectivity inefficient.

It is essential to propose an optimization and simulation model that explicitly considers resilience factors in cities such as biomimetization, public systems, social resilience, fast and safe traffic. In [2], it is exposed how poor traffic management, significantly increases the energy costs of a city. The author concludes that an increase in the volume of traffic causes the logistic flow of the city to decrease, rendering the city.

In Javier Prado expressway [x] the authors expose a poor management of traffic.

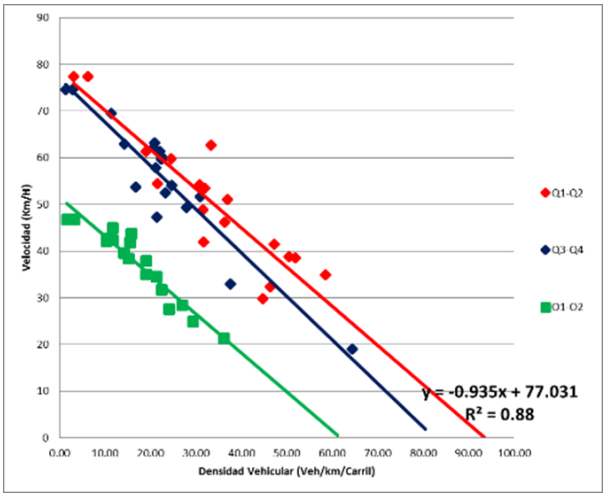

Figure 2. Average speed versus Density curves – Sense West-East [x].

The curve relating the average speed versus vehicle density, is a line of negative slope. This curve shows the quasi indirectly proportional relationship of one-way traffic density with speed. Higher density - higher saturation of the road- lower the operating speed of the track. So this curve shows the degree of influence of the saturation of way in the formation of the phenomenon of congestion.

The TSE strategy is related to the inference and prediction of traffic state variables, mainly based on processes to estimate traffic through a priori knowledge and partial observations, data entry and traffic flow models [8].

Generally, the entry or formation of the database has three problems: limited technology, limited financing and data with disturbances. The data can be collected statically or dynamically, in real time or historical data and can be found aggregated or disaggregated; As part of the research, it is proposed to collect a disaggregated, static or dynamic data sample -the one that most benefits the proposed model-, in segments that provide small databases, the disturbances resulting from the measurement of them will be improved with the use of a mixed neural network, which will classify the training groups with an adaptive network such as Self Optimization Maps SOM, the data will be corrected with a backpropagation network BP, and the use of wavelets (the best for each case.) The database thus improved can be used to generate forecast data using the Kalman filter [11]; and the study of the periodicity of occurrences and location of points of time-frequency relationships, such as the start of peak time using wavelets [1].

The improved database will be used to predict the state variables by means of the finite element method [6]. Finally,

from the calibrated data and partial differential equations, a macro-model for a local express route will be proposed [12]. Finally, a roadmap is proposed following previous objectives and restrictions mentioned, which can predict the global behavior of traffic flows to forecast the resilience of urban logistics.

The general objective of the project is to improve the resilience of the urban logistics of the city through the prediction of traffic at unobserved points and infer future conditions through technologies of estimation of traffic status TSE. Specific objectives:

1) Establish quantitative and qualitative relationships between traffic state variables of expressways and factors that improve the resilience of a city.
2) Build a database referring to the traffic state variables at points strategically located in a road network, according to duly selected scenarios.
3) Develop algorithmic variants to the Kalman filter method and wavelets, to strengthen the constructed database that helps to calibrate the proposed model.
4) Develop a hybrid methodology based on neuro-fuzzy algorithms and finite elements, to improve the process of simulation and optimization of traffic.
5) Propose a macromodel simulation based on TSE, which considers the improvement of urban logistics, applicable to local expressways.

It is proposed a roadmap of four steps to accomplish this propose are: (i) first do a literature review about optimization and simulation previous experiences and database about current state urban logistics. Second determine a qualitative and quantitative traffic system management, designing scenarios that predict traffic and its state variables considering their relationship. Third an optimization and simulation model that assessment resilience level, a calibration database protocol will valid the resilience model. Fourth, a final traffic management resilience system model to be tested to simulate different flows users on city road network.

III. METHODOLOGY AND WORK PLAN

The influence of urban resilience factors on traffic state variables is studied and sensitivity relationships are established between factors and variables that contribute to the construction of a new simulation model. Data is collected at several points of a local road network, which will preferably be disaggregated; with traditional methods such as cameras, simulation of travel in satellite tracking programs. To determine frequencies of passage and periodic occurrences, spectra similar to Fourier but with wavelets will be prepared, selecting an adequate family of the latter to study the initial conditions of changes in the road network. With the established database it is necessary to calibrate the algorithm proposed in the third specific objective, the results of this calibration process serve to infer points not observed through a micromodel simulation.

The research methodology is graphed in the next concept map.

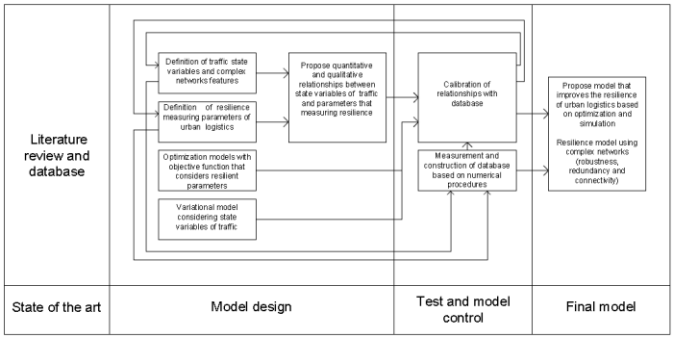

Fig. 3, The research methodology.

The first part is the study of variables and numerical models that relate resilience and traffic state variables; this comprises a comprehensive review of the state of the art of resilient cities, urban logistics improvement processes, traffic micromodels and traffic macro-models to Establish how the resilience factors of cities and traffic state variables are related in proposed scenarios. The second one is referred to construction of database and algorithmic variants for its improvement, as a filtering algorithm to improvement of data collected in the field, prediction algorithm to create complement synthetic database. Third part is referred to development of hybrid methodology, this methodology has two parts; the first is improve simulation with SOM, support vector machine or genetic algorithm (the one with the best performance) and the second improve traffic variables with finite element. The results of methodology be calibrated with the database. Finally, it will be developed a macro-model proposal that considers the increase resilience factors of urban logistics related to traffic status variables.

IV. DISCUSSION AND CONCLUSION

The inference the state of a road network economically and accurately is an open problem. The collection of data by drones, improves the quality of the results since it can be done simultaneously, however ensuring the non-occurrence of accidents in a city (e.g. falling of the drone and damage to people is a possibility that limits this technique in cities). Improving the construction of the database through numerical technique is an alternative, but it must be justified and adequately monitored.

Traffic solutions are in themselves a gradual process, they are not sudden (due to the customs of the people, e.g. the trips of the same are carried out from home to work and vice versa). This is a fundamental reason, to consider that any improvement must be strongly related to the increase in the resilience of the city and be carried out gradually.

The proposed methodology, with greater coverage in the data collection process, is replicable to the road network as a whole and not only to the impact produced by expressways, any change, especially in studies of road impact should be strongly related to the increase of factors that improve urban resilience.

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