Integrating Road Safety in an Investment Plan for the Mesoamerican International Corridor

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Abstract

In 2002, seven countries (Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama) signed an agreement to define standards for their international road network. In 2010, in partnership with the Inter-American Development Bank, these countries launched development of an investment plan for the International Mesoamerican Corridor on the Pacific side. The 3,244-km corridor runs from Puebla, Mexico, to Panama City, Panama.

This investment plan was to prioritize corridor road construction and upgrade for the next five years. The traditional approach to such a project would primarily use the road investment appraisal model HDM4 (pavement analysis). However, the prioritization process included many other components such as road safety, environmental assessment, citizen security (from criminal assault), border control, and international freight transportation.

The road safety component included both a road safety review (RSR) performed by Lanamme, University of Costa Rica, and iRAP (International Road Assessment Program). It was demonstrated that both studies were necessary and complementary. During the data collection period, IDB and country governments also ran a campaign to raise local awareness about the importance of road safety.

This paper presents the methodology used by the road safety review for the 3,244-km corridor. The iRAP generated a detailed inventory, road safety appraisal and countermeasures limited to the assets of road infrastructure. The RSR was an independent study taking into account road infrastructure, the human factor, road consistency, land use, freight transportation, road geometry, and particular problems of the region with respect to road safety. This RSR also recommended countermeasures for government programs in the short term (maintenance programs), medium term (local road improvement projects), and long term (road construction).

Résumé

En 2002, huit pays (Mexique, Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica et Panama) ont signé un accord international visant à définir des normes pour leur réseau routier international. En 2010, ces pays ont lancé le développement d'un plan d'investissement pour le corridor international de la Méso-Amérique proche à la côte Pacifique, en partenariat avec la Banque interaméricaine de développement (BID). Ce corridor a une extension de 3 244 km entre la ville de Puebla au Mexique et la ville de Panama au Panama.

Le plan d'investissement donnerait la priorité à la livraison de la construction et modernisation des routes à travers le corridor pour les cinq suivantes années. L'approche traditionnelle pour ce type de projets a pu être faite principalement à l'aide du Modèle d'évaluation des investissements routiers HDM4. Cependant, ce projet a eu une approche plus globale, y compris le modèle HDM4, la sécurité routière, l'évaluation environnementale, la sécurité des citoyens, le contrôle des frontières et le transport international de marchandises.

L'analyse de la sécurité routière a été réalisée à travers une évaluation de sécurité routière (ESR) réalisée par le Laboratoire de matériaux et modèles structurels de l'Université du Costa Rica (LanammeUCR). Le iRAP (Programme international d'évaluation des routes) a aussi évalué le corridor. Il a été démontré que les deux études étaient nécessaires et complémentaires. Au cours de la période de la collecte des données, la BID et les gouvernements ont également fait une campagne sur ce projet dans chaque pays afin de sensibiliser aux communautés locales sur l'importance de la sécurité routière.

Cet article présent la méthodologie utilisée pour l'évaluation de la sécurité routière dans le corridor de 3 244 km. Le programme iRAP fournit un inventaire, une évaluation de la sécurité des routes et des contre-mesures respectives limitées à la section transversale des routes, mais l'évaluation de la sécurité routière (ESR) a couvert une analyse plus extensive. Cette évaluation (ESR) a été une étude indépendante qui comprenait l'infrastructure routière, le facteur humain, la cohérence de la route, l'utilisation du sol, le transport de marchandises, la géométrie de la route, et les problèmes particuliers de la région en matière de sécurité routière. L'évaluation a également recommandé des contre-mesures pour les programmes gouvernementaux à court terme (des programmes de maintenance), à moyen terme (projets d'amélioration des routes locales), et à long terme (construction de routes par la BID).

INTRODUCTION

The Pacific Corridor of the Mesoamerican Project

The Mesoamerican Project is the mechanism established by Mesoamerican countries (Mexico, Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Colombia and the Dominican Republic) to facilitate design, financing and implementation of regional integration projects in infrastructure, connectivity, and social development.

At the 11th Summit of Tuxtla held July 2009 in Costa Rica, country leaders agreed to adopt the International Network of the Pacific Corridor of Mesoamerican Highways (RICAM[1]) program as regional priority and assign financial resources to upgrade corridor standards and address harmonization of freight transportation regulations (weights and dimensions) and road safety issues.

The Pacific Corridor follows the Pacific coast from Puebla (Mexico) to Panama City (Panama), for a total length of 3,244 km. The investment to be made in this existing corridor will be US$ 2.7 billion for upgrade.

Figure 1. Pacific Corridor of the Mesoamerican Project (Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama)

[1] RICAM is an 8,977 km-long highway network divided in two main corridors: Pacific Corridor (3,159 km) and Atlantic Corridor (1,745 km), along with regional arterials and minor roads (4,073 km).

In addition, major problems were identified at the border crossings of each country, such as significant corridor-wide delays for freight transportation and discrepancies between regulations on vehicle weights and dimensions, making efficient transportation of goods difficult.

In partnership with the Inter-American Development Bank, in 2010 the Mesoamerican countries launched the development of an investment plan for the International Mesoamerican Corridor on the Pacific side.

Master Investment Plan for the Pacific Corridor

The Inter-American Development Bank (IDB) is leading operations to upgrade the Pacific Corridor and provides project financing to country governments for the region's economic and social development. The objective is to upgrade the Mesoamerican Pacific Corridor and turn it into the main corridor of transport and trade for integration of the Mesoamerican region, with highest international quality and safety standards.

IDB contracted several consulting firms to draft the investment plan to prepare pre-investment and bidding documents, aimed at ensuring standards of excellence for the Pacific Corridor, maintenance, and operation for a period of at least twenty years.

This investment plan was to prioritize delivery of road construction and upgrade throughout the corridor. The traditional approach for this type of project would primarily be to use the road investment appraisal model HDM4, which only takes pavement structure into account.

The investment plan included a range of components developed by many consultants for each area: (1) pavement, (2) road safety, (3) environmental assessment, (4) citizen safety (meaning road user safety from criminal activity), (5) border control and international freight transportation at a regional scale, (6) database design, and (7) corridor maintenance management. These components have been incorporated to ensure an efficient transport system and improve quality of life for users and the environment.

Figure 2 illustrates components taken into account for the investment plan and upgrade programming for the road network. In all of the components, the challenge has been to integrate wide variation in local characteristics and in the laws and policies of seven different countries.

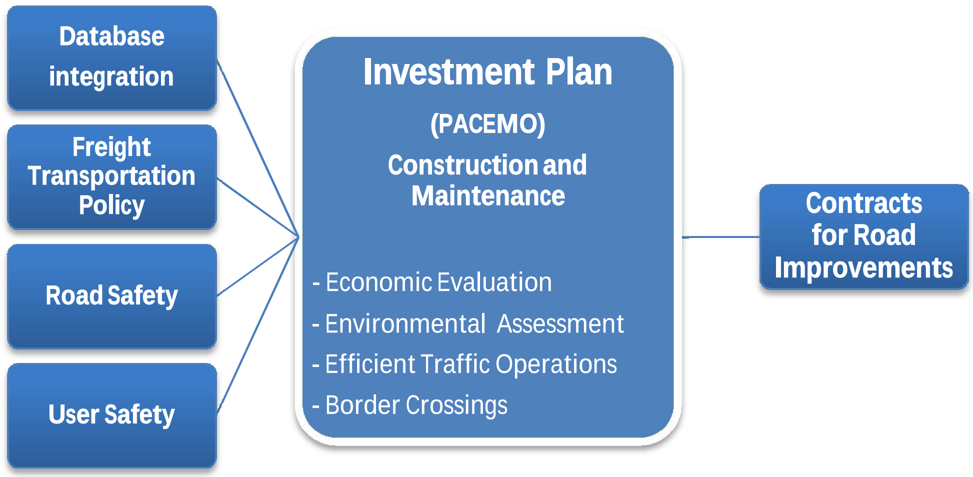

Figure 2. Components of the Master Investment Plan of the Pacific Corridor

OBJECTIVES

General Objective

Evaluate road safety and provide network-level countermeasures for the 3,244 km-long Pacific Mesoamerican Corridor for incorporation in the road upgrade plan

Specific Objectives

1. Prepare a video survey of road assets, and road safety appraisal techniques to identify common issues along the road network
2. Perform field inspections by an independent road safety auditor
3. Develop an independent road safety review of the existing Pacific Corridor
4. Identify risk spots in road safety and incorporate them for prioritization in the investment plan
5. Perform a star-rating system to indicate the influence of road attributes throughout the Pacific Corridor using the International Road Assessment Program (iRAP)
6. Conduct a public education campaign to raise awareness among local residents along the corridor
7. Create awareness in the engineering community about incorporating road safety in planning and design of road projects

Scope

This paper includes only the road safety component that was part of the master investment plan for the Pacific Mesoamerican Corridor. The project aims to upgrade the existing road. The plan does not include any freight movements by rail due to lack of infrastructure across the countries.

METHODOLOGY

Conceptual Framework of the Road Safety Project

The objective of the road safety project was to provide recommendations for infrastructure improvement to the Pacific Corridor at a network level. All of the findings of the network appraisal contributed in defining the investment plan. Given IDB's commitment to quality-of-life improvement, during the data collection period local awareness-raising campaigns were carried out about the importance of road safety.

The five main consultants in this project were:

1. Data collection team: video survey, collection of pavement data (roughness and rutting), and road geometry data for the entire 3,244 km of road network
2. Data reduction: processed the video and pavement survey under the supervision of the iRAP program
3. iRAP program: in charge of quality control for data reduction, formulation of countermeasures for road safety, rating of the road network and costs at a network level
4. Local engineer for each country: provided the road safety team with accident data and local information
5. Road safety team: independent team that traveled along the entire network to conduct a Road Safety Review; identified priority risk sections for improvement and analyzed accident data and the video survey. After conducting these studies, the team also integrated iRAP results to provide an end result for the road safety project.

In each country there was a road safety technical committee representing the country Transportation and Public Works ministries. This committee was responsible for monitoring, reviewing and approving the study. Figure 3 presents the organizational chart for implementation of the road safety project.

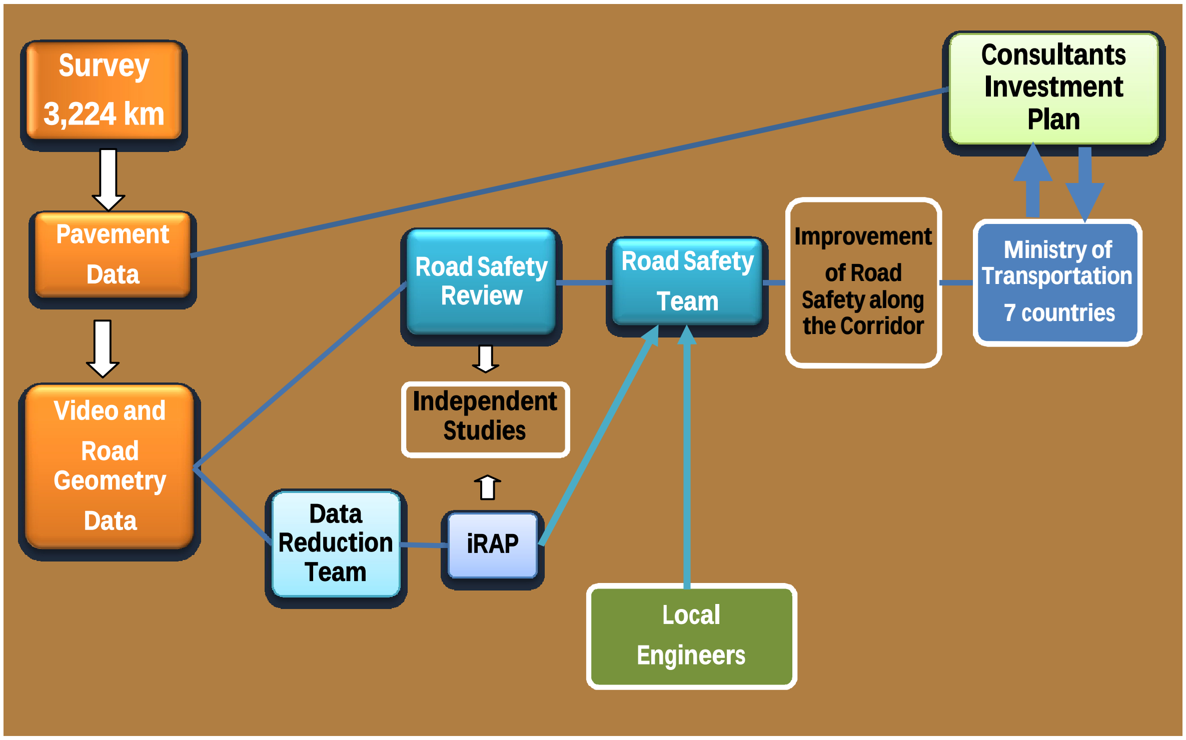

Figure 3. Organizational Chart of the Road Safety Project

As shown above, the Data Collection team collected pavement information (used for the road investment appraisal model HDM4), videos and geometry data for the Pacific Corridor. This information was generated for the iRAP analysis and Road Safety Review. It should be noted that the two studies were prepared independently. The Data Reduction team processed information for the iRAP program, local engineers collected additional information from each country (e.g., accident data), and the Road Safety team executed the independent road safety review.

Once these studies were concluded, the Road Safety team integrated all of the results and generated recommendations for road safety improvement in the corridor and selection of priority sections (risk) in the investment plan at a network level.

Data Collection Process

The four-week tour encompassed the seven countries of the Pacific Corridor RICAM (Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama), beginning on May 10th, 2010, in the town of Minatitlan, Mexico and ending July 8th, 2010, in Panama City, Panama.

The team named this trip the "*Road Safety Caravan*". Considering that road safety is affected by the human factor, vehicles, engineering and the road environment, the approach contemplated more than just engineering objectives. For this reason, data collection was accompanied by an awareness campaign to promote a social and political culture that aspires to be free of road traffic incidents.

The aim of the campaign, called *“Safer Roads for Everyone,”* was to raise public awareness about the need to take action, encourage a proactive attitude and promote understanding of the role of personal responsibility in preventing road traffic incidents.

Each country held an event organized by its transportation ministry in partnership with IDB and local authorities. All of the transportation ministers took a leadership role, addressing a message about road safety to the public which was broadcast by top journalists and media. The event was attended by police officials, health services, and schoolchildren. Figure 4 shows the official event held in Costa Rica.

Figure 4. Official event held by the Ministry of Transportation and Public Works in Costa Rica

As part of the campaign, the orange-colored vehicle collecting road data was called “The Orange Angel” and the message sent to the public was that there was a *Guardian Angel* on the roads looking after their safety. “The Orange Angel” toured the corridor with police escort and journalists. Figure 5 shows the “The Orange Angel” traveling along the corridor.

Figure 5. “The Orange Angel” in the Road Safety Caravan along the Pacific Corridor

The Road Safety Caravan was made up of the Data Collection team, one road safety auditor from the Road Safety team, support staff, IDB staff, local authorities, police escort, journalists and staff from the transportation/public works ministry of each country. The distance covered is shown below in Table 1.

Country	Distance (km)
Mexico	**1,108**
Guatemala	**302**
El Salvador	**364**
Honduras	**127**
Nicaragua	**341**
Costa Rica	**496**
Panama	**497**
Total	**3,244**

Table 1. Length of the Pacific Corridor

The “Orange Angel” used in the survey consisted of a van equipped with six high-resolution cameras that took images every 2.8 meters, along with a global positioning system, laser profilometer that measured the International Roughness Index (IRI), and a laser meter to measure pavement rutting. It also measured horizontal curves and road grade.

Five of the six high-resolution cameras provided detailed, 360-degree imagery, making possible precise measurements of the different road elements. These inspections generated a permanent video and database record that can be easily reviewed. The sixth camera was aimed directly at the pavement surface to record deterioration of the pavement. Figure 6 shows features of the Orange Angel, and Figure 7 presents panoramic images used for the road safety analysis.

(a) Six cameras installed in the vehicle

(b) Rutting measurement

(c) Profilometer for IRI survey

Figure 6. Features of the Orange Angel

Figure 7. Panoramic images (front and back) from the survey

RESULTS AND DISCUSSION

International Road Assessment Project (iRAP)

The iRAP program performs a road assessment by measuring risk associated with road attributes expressed in star ratings that can provide a better indicator of the influence of road attributes on risk. The road is rated by stars, classified according to vehicle occupants, motorcyclists, pedestrians and bicyclists.

The safest roads (4 or 5 star) have road safety features appropriate for prevailing traffic speeds. They tend to be straight, have two lanes in each direction separated by a wide median, good line marking, wide lanes and sealed shoulders, safe roadsides and good provision for bicyclists and pedestrians, such as dedicated paths and crossings.

The least safe roads (1 and 2 star) do not have road safety features appropriate for the prevailing traffic speeds. They tend to carry two-way traffic with only one lane in each direction and have lots of curves and intersections, narrow lanes, gravel shoulders, poor line marking and unprotected hazards such as trees, poles and steep embankments close to the side of the road. They are also unlikely to have dedicated facilities for bicyclists and pedestrians.

The iRAP program also performs Safer Roads Investment Plans, which considers the condition of existing roads, estimated number of fatalities on existing roads, and the application of proven engineering countermeasures when justified. The economic value of the countermeasures is assessed by estimating the likelihood of a crash or severity reduction outcomes expressed as a monetary figure.

For the Mesoamerican Project, the survey information provided by the “Orange Angel” was sent to the Data Reduction team. Each road design element was measured and rated according to iRAP protocols. The team made desktop inspections by conducting a virtual drive-through of the road network, looking at video frames at 100m intervals. The raters use specialized software to make accurate measurements of such elements as lane widths, shoulder widths, and distance between the road edge and fixed hazards like trees and poles. The main products that the iRAP program delivered are described as follows:

- Star rate mapping for vehicle occupants, motorcyclists, pedestrians and bicyclists. (Figure 8 provides an example.)
- A database of more than 30 road attributes (i.e. Speed, lane width, paved shoulder with, curvature, quality of curve, delineation, side friction, pedestrian cross facilities, etc)
- Countermeasure proposals and economic assessments for 100m sections of road
- Training for Ministry of Transportation and Public Works staff in the region

The economic assessment based on countermeasure proposals was of significant importance for the economic evaluation in the investment plan. This project was done at a network level for strategic planning of needed road safety investments in the Pacific Corridor.

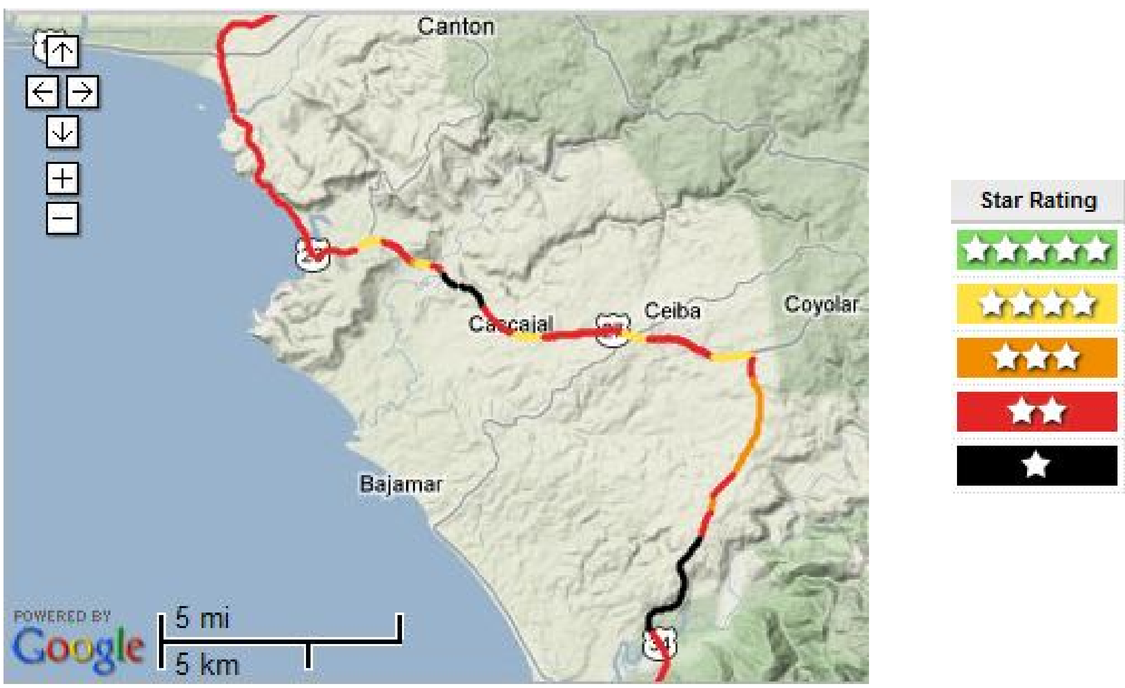

Figure 8. Example of star rate mapping by iRAP

Table 2 and Figure 9 show the results for the star rating by country.

Star Rating	Mexico	Guatemala	El Salvador	Honduras	Nicaragua	Costa Rica	Panama
	%	%	%	%	%	%	%
	0	0	0	0	0	0	0.4
	21	5	3	1	3	1	18.1
	49	17	10	21	11	3	47
	21	36	66	51	60	44	27.5
	9	42	21	27	26	52	7

Table 2. Percentage of stars per country

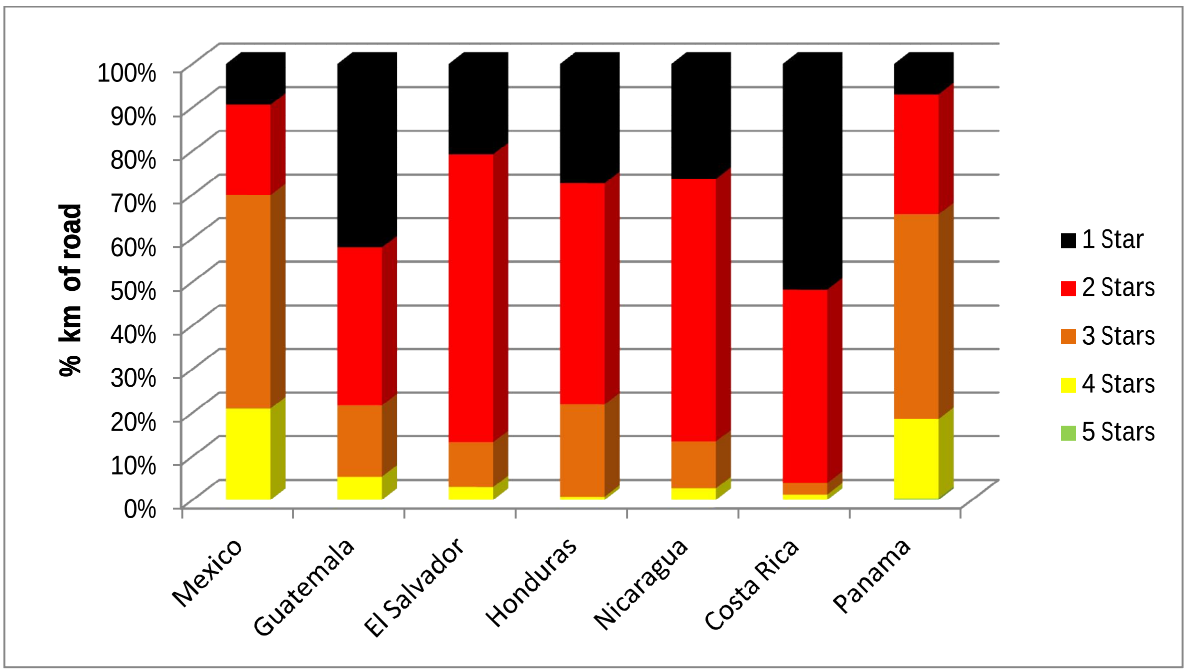

Figure 9. Star rating results from iRAP

The results above from the iRAP rating show that Costa Rica and Guatemala have the lowest performance (1 star: 52% for Costa Rica and 42% for Guatemala), followed by El Salvador (66 % of 2 stars). While Mexico and Panama have the highest amount of 4 stars (21% for Mexico and 27.5% for Panama).

Road Safety Review

The objective of the Road Safety Review (RSR) was to perform a direct observation of the Pacific Corridor, report on potential road safety issues, and identify opportunities to improve safety for all road users.

The Road Safety Review was conducted by the Road Safety team. One road safety auditor was part of the Road Safety Caravan and made visual observations of the corridor. During this tour the road safety auditor identified risk spots that needed to be addressed in the investment plan. IDB had requested to identify at least one risk spot for every 100 km. Technical criteria for selecting the risk spots was defined by the Road Safety team.

Since the iRAP program generates an inventory, road safety appraisal and countermeasures limited to the pavement section of the road, the Road Safety Review was performed to cover a wider analysis taking into account the road infrastructure, human factor, road consistency, land use and the relationship between the road environment and the user, freight transportation, road geometry, and particular problems of the region in terms of road safety. Special attention was paid to the most vulnerable users (pedestrians and cyclists). Finally, the Road Safety Review was aimed at integration of the corridor and road consistency to accommodate freight vehicles and improve road safety standards.

With respect to risk spots identified during the tour, the following aspects were used as selection criteria:

- Vulnerable road users: pedestrians and cyclists
- Urban road: road environment and land use that cause conflicts among the different users (e.g., conflict between freight vehicles and pedestrians or conflict between a high speed road and pedestrians due to bus stops across the corridor)
- Rural road: sharp curves and geometric design
- Unprotected roadside and precipices
- Safety conditions on bridges
- Poor visibility (especially during rainy and night conditions) due to the absence of illumination and pavement markings

During field inspections, 1,033 risk spots were identified. Figure 10 presents a summary of total risk spots identified on-the-ground by the road safety auditor and the amount of spots per 100 km.

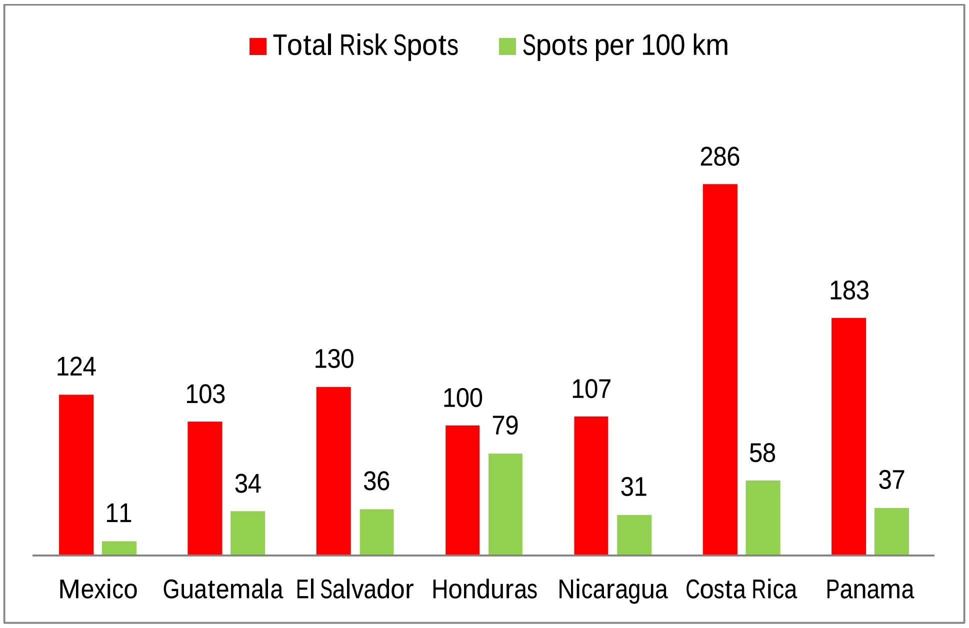

Figure 10. Risk Spots by Country

The figure above shows that Costa Rica and Honduras have more risk spots per 100 km length. Guatemala, El Salvador, Nicaragua and Panama have a similar performance; while Mexico has the lowest risk spots per 100 km length. The lowest risk spots in Mexico is due to the fact that the international corridor does not go through urban areas, therefore, it reduces the risk of vulnerable road users. The most critical factor for this performance was that the alignment of this corridor goes through many urban areas, hence increasing risk deriving from conflict between vulnerable road users and vehicles.

As it has been mentioned before, these results may vary from the iRAP star rating due to the fact that iRAP analyses the assets within the pavement, while the road safety auditor analyzed more variables including the land use and human behavior. Figure 11 illustrates some of the conditions analyzed by the road safety auditor.

One of the limitations was the lack of data available. The road safety analysis could not take into account any collision database. Due to this situation, most of the analysis was based on field observations and visual assessment was of significant importance.

(a) Safety condition on bridges

(b) Vulnerable users and conflicts in urban areas

Figure 11. Example of conditions evaluated for risk spots

After the field inspections, the Road Safety team proceeded to analyze all the images taken during the data collection process, taking land-use and geometric features of the road into consideration. Each country government divided the corridor into sections and the RSR reported its findings and countermeasures following this structure. Altogether the corridor has 137 sections, each averaging approximately 23 km long. The RSR reported countermeasures for government programs in the short term (maintenance programs), medium term (local road improvement projects), and long term (construction and upgrade of the Pacific Corridor).

Seven main common issues were identified:

1. Road consistency across the countries and the relationship between the road and land use due to conflicts amongst the different users
2. Road design and facility design at international borders
3. Vulnerable road users: pedestrians and cyclists
4. Lack of pavement markings and maintenance
5. Roadside (obstacles on the side of the road and absence of shoulder)
6. Guiderail condition

7. Safety conditions on bridges

Signage consistency is important for road safety and integration of the corridor in order to deliver a clear and appropriate message to the road user. There were issues concerning the retroreflectivity of pavement markings and vertical signs, and some areas had no pavement marking or lighting whatsoever, posing risks to users under night-time and rainy conditions.

The whole corridor needed roadside improvement due to obstacles such as trees, culverts, etc.; many sections lack a shoulder, and the guiderail condition increases the severity of the injuries in case of accident.

The road facility design needs to be upgraded to accommodate freight vehicles. The alignment of this corridor goes through many urban areas (Figure 12), hence increasing risk deriving from conflict between vulnerable road users and vehicles. In road sections with significant flow of pedestrians and cyclists there was no separation between these vulnerable users and other road users. Public transportation and bicycles are the primary modes of transportation for the low- and middle-income population in some of these areas, which needs to be taken into account for corridor upgrade.

Figure 12. Example of corridor alignment through an urban area

CONCLUSIONS

The International Network of the Pacific Corridor of Mesoamerican Highways (RICAM) aims to promote area integration and improve regional competitiveness by reducing transportation costs and travel time while boosting safety from Mexico to Panama. Because there are seven countries involved, the challenge is to harmonize policies, laws, and guidelines along with the characteristics of the road network.

The Mesoamerican Project investment plan at network level constitutes a comprehensive study of pavement condition, road safety for users in general, environment, citizen safety (safety from criminal activity for users), border control, and international freight transportation at a regional scale.

Recognizing that road safety is affected by human as well as vehicle, engineering and road environment factors, the approach has embraced both engineering and social perspectives, as reflected in the awareness campaign called “Safer Roads for Everyone” carried out during the data collection process.

The Inter-American Development Bank assigns high priority to this issue and therefore aims to minimize human, social and economic losses resulting from inadequate road safety practices.

As a result of this project, there is much more awareness at all levels, in the political and technical community and society at large. The road safety study helped build capacity and technical knowledge about road safety engineering. In partnership with IDB, the country governments are launching road safety contracts to improve specific conditions in corridor sections, as well as national road safety strategies and capacity building for stakeholders.

The experience of incorporating both the International road assessment project (iRAP) and an independent road safety review has led to a comprehensive approach to road safety. It is highly recommended that both analyses be incorporated when preparing investment plans.

At the network level, an asset inventory on road safety is needed. Evaluation of a road network requires the use of data collection tools and data reduction methods in order to process a massive amount of data. iRAP offers a good methodology for performing this task, as well as an economic analysis that can be incorporated in a strategic investment plan. One of the benefits of the star mapping system is that it facilitates government and society awareness about the safety of roads.

However, this asset inventory is limited to the pavement section and should be complemented by a road evaluation that incorporates analyses of land use, geometry, human factors, road consistency, local conditions of the road, and local behavior of the road user. Incorporating a road safety review in this project had very positive results for the project overall.

Integrating the two methodologies leads to more efficient countermeasures at a network level, since the final product generates recommendations for government programs in the short term (maintenance programs), medium term (local road improvement projects), and long term (road construction).

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