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AS-H04

HOW TO UNDERTAKE ROAD SAFETY ASSESSMENT FOR TOD AREAS

Measures for conducting a road safety assessment while assessing the TOD readiness of a city.

Type: Step-by-Step Guide

WORLD BANK GROUP | TOD | Global Platform for Sustainable Cities | gef | UKaid from the British people | GRSF Global Road Safety Facility | IBI | WRI INDIA

As an extension to earlier AS-A01 section to undertake TOD readiness assessment for a city, a road safety assessment needs to be carried out. Along with advocating for a TOD project to address road safety challenges around a transit station and the city at large, this assessment also helps in identifying gaps at the institutional levels, critical areas in the network that require attention and can thus be prioritized, and provide mitigation strategies and designs to address the same. Below are the steps to be undertaken to carry out a road safety assessment while assessing TOD readiness.

01 ROAD SAFETY CAPACITY REVIEWS

The first measure looks at assessing 'efficiency and effectiveness' of the various existing policies and regulatory frameworks for road safety, and institutional setup for carrying out safety measures that are available at the local, regional, and national levels. These are analyzed based on their capacities to execute planning, design and implementation of road safety measures and how they can be suitable in supporting a future TOD project based on the type of transit services, scale of TOD and urban context.

Along with policy and regulatory assessment, it is essential to identify a lead implementation agency, and assess the existing expertise to determine its ability to efficiently deliver road safety considerations while executing a TOD project.

[Refer to AS-H01 *'How to undertake Rapid Transit Alternative Analysis' for TOD readiness assessment and* IM-H01 *'How to Undertake Capacity Building' and* IM-P01 *'Capacity Development Strategy Terms of Reference'*

02-A DATA COLLECTION

For a road safety assessment, two types of data are required to be collected:

1. **Physical context data**

   Information about the existing context of the city and the station areas is required for the assessment. A road inventory data is a critical information required for a road safety assessment as it provides information of the physical conditions that may have led to a crash. The various kinds of information collected as part of the road inventory have been detailed out in (A) PHYSICAL CONTEXT DATA

   Along with a road inventory, information regarding the larger urban fabric of the city and within the station area such as socio-economic demographics, urban density, land use, transportation network, traffic counts etc will also be collected to support the road safety assessment.

DATA SOURCES

- Local Government
- Census Data
- GIS Data with the city and its various departments such as transport, planning etc.

2. **Road crash data**

   Road crash data includes details specific to the road crash. These details include variables such as the date, time, location and type of crash, characteristics of the persons and vehicles (modes) that are involved in the crash, and the severity of the crash including injuries and fatalities. These have been detailed out in (B) ROAD CRASH DATA COLLECTION.

DATA SOURCES

Primary Source

- Police Records

Secondary Source

- Hospital Records
- Vehicle Insurance Records

02-B DATA ANALYSIS

The next stage of the road safety assessment is to analyze the data collected and identify trends and priority areas for interventions. The three types of analyses and their relevance to TOD readiness have been explained in C **DATA ANALYSIS.**

In absence of reliable and/ or sufficient data for assessment, a 'crash-conflict analysis' may be undertaken as alternative. It involves a count of all "near-miss" incidents that could potentially lead to a crash. This has been highlighted in the D **CRASH CONFLICT ANALYSIS.**

03 ROAD SAFETY ENGINEERING TOOLS

Many proactive tools for road crash risk assessment have been developed which provide a holistic assessment of the road by considering various physical and contextual elements present. These risk identification tools are adopted at different stages of implementation of a road design and may be undertaken for both new roads or modification to an existing road and help in identification solutions to the risks identified and prioritization of suggested interventions. These tools are designed for all kinds of roads, however, the assessment carried out is modified to cater to the context of TOD influence area within a framework to ensure functionality, homogeneity of volume of users, and predictability for all users using the roads and road network within the TOD area.

Following are four different tools that have been further elaborated in E **ROAD SAFETY ENGINEERING TOOLS**:

1. Road Safety Impact Assessments or RSIA
2. Road Safety Audits or RSA
3. Road Safety Inspections or RSI
4. Different road assessment programs

A PHYSICAL CONTEXT DATA

Evidence based advocacy helps in decision making and prioritization of funding and project implementation. Data collection and proper analysis of the same helps in gaining support from the community and various stakeholders and provides the basis for making relevant improvements. Data based analysis helps in advocating for decision making and prioritization for funding and project implementation, and most importantly generating support from the community and various stakeholders involved in the project. For undertaking a road safety assessment, its is essential to prepare a road inventory as basis for crash data analysis. This information may typically be sourced from the transportation department preferably as part of city-wide GIS data. A typical inventory includes:

FUNCTIONAL ATTRIBUTES OF THE ROAD

1. **Type of road:**
   - Arterial
   - Connector
   - Shared street
2. **Presence of NMT facilities:**
   - Sidewalks
   - Bike lanes
   - Multi-use trails
3. **Use of transit along the ROW and type:**
   - Public transport- buses and feeder services
   - BRT
   - Streetcars
   - Light rail
   - Mass transit- Metro, Commuter rail

PHYSICAL CHARACTERISTICS OF THE ROAD

1. **ROW:**
   - Width
2. **Vehicle travel lane:**
   - Number of lanes and Directionality- One-way or Two-way
   - Width
   - Type of separator markings or medians
   - Width of median
   - Type of median- raised, landscaped, barriers
3. **Walking infrastructure:**
   - Availability- none, on one side or both sides
   - Width
4. **Cycling Infrastructure:**
   - Availability- none, on one side or both sides
   - Type- shared lane, cycle lane, Contra-flow lane, Cycle track, Bi-directional track, multi-use trails etc
   - Width
   - At grade or raised
   - Buffer type and width
5. **Transit infrastructure**
   - Grade- Elevated, at-grade, underground
   - Dedicated lanes for transit or Shared lanes
   - Width
   - At grade or raised
   - Buffer type and width

USER AMENITIES ALONG THE ROAD

1. **Intersections**
   - Signalized or unsignalized
   - Crosswalk width
   - Availability of pushbuttons
   - Universal accessibility and Tactile surfaces
2. **Mid-block crossings**
   - Crosswalk width
   - Pushbuttons, HAWK beacons etc
   - Universal accessibility and Tactile surfaces
   - At grade or raised
   - Any other types of crossing: Foot-over-bridge (FOB), underpass
3. **Street amenities**
   - Streetlights,utility boxes
   - Landscape- trees, planters, furniture
   - Information/ signage
   - On-street vending
4. **Parking facilities:**
   - Bike racks, Bike share
   - Vehicular parking- parallel, angled
   - Metered or free parking
5. **Transit amenities:**
   - Bus stops, BRT stops, train stations
   - Ticket facilities

SURROUNDING SOCIAL AND URBAN CONTEXT

Apart from a road inventory, other information about the context, would help in supporting the road crash assessment and also assist in determining the TOD readiness of the place. These include:

1. **Surrounding context:**
   - Greenfield
   - Suburban
   - Urban
2. **Socio-economic demographic data** of the population within the station area –
   - Population density
   - Income levels
   - Vehicle ownership
   - Mode choice etc
3. **Land use pattern** to help understand movement patterns, identify activity generators etc
4. **Traffic count** of the number of vehicles, cyclists, and pedestrians passing through

B ROAD CRASH DATA COLLECTION

To understand road safety management, it is essential to acquire and analyze road crash data as they help in scientifically identifying concerns and equip stakeholders in decision making processes. Therefore, a robust dataset is required to assist in the analysis. Often road crash data that is collected is either insufficient to make assessments or are incomplete and may also have human errors during the collection and recording stages. A typical road crash data set contains different types of variables that must be collected. However, depending on the local context and the efficiency of collection agency, this information maybe basic or detailed.

Following is set of information that is collected as part of road crash data:

DATE & TIME	Recording of date and time variable allows for seasonal and hourly comparisons of the incidents. Frequent occurrences of road crashes during a time of the day can be compared with the local traffic data to establish if any correlation exists between the occurrences and traffic volumes. Seasonal variations also impact the occurrences of road crashes. For example, in cities where it snows, formation of black-ice can increase number of incidents. Some cities also have dense fogs during early hours in winters. This reduces visibility and leads to early morning crashes.
CHARACTERISTICS OF PERSONS INVOLVED	Crash data must include the number of persons involved in the incident and other basic information. Variables that need to be recorded about the persons involved in the crash include: • Road user type (pedestrian, cyclist, vehicle driver, vehicle passenger etc) • Age and gender • Persons with special needs including disabled and pregnant women • Physical condition of the users including level of alcohol in the body • Details about use of any safety equipment such as protective gears, seat belts etc • Type of injury sustained This information helps in identifying the most vulnerable users and making a case for road safety. An area with higher number of seniors as vulnerable users may require interventions like longer crossing times or where minors are the most vulnerable users may require measures like wider or protected buffers. It also helps in understanding the risk factors.
CHARACTERISTICS OF VEHICLE	Data also should be collected about the vehicles involved in the crash including: type, age, country, safety equipment if any, date of last periodical technical check according to applicable legislation.
CRASH SEVERITY	Crashes are also defined by its severity – which is based on the impact on the persons involved: • **Fatal injury:** any person killed immediately or dying within a stipulated number of days (varies based on country) • **Serious injury:** Injury that requires admission to hospital for at least 24 hours, or specialist attention, such as fractures, concussions, severe shock and severe lacerations • **Other/minor injury:** Injury that requires little or no medical attention (e.g. sprains, bruises, superficial cuts and scratches) • **Property damage/non-injury:** No injury is sustained as a result of the crash but there is damage to vehicles and/or property Not all crashes are fatal in nature. However, the severity of the crash can also be determined by the level of injury sustained. High frequency of similar type of minor crashes may require a smaller tactical intervention whereas frequent fatal crashes may require stricter measures.

(Continued.)

B ROAD CRASH DATA COLLECTION

CRASH TYPE	Information on type of crash including modes involved for example vehicle-vehicle or vehicle-pedestrian or vehicle-bicycle etc during the crash needs to be recorded. Reasons for the crash can be collected through first-hand information from bystanders and from those involved. Additionally, photographs and closed-circuit television (CCTV) footage from nearby buildings and other means may help in placing the events of the crash. Other information that is required includes: • Maneuver of vehicles during the crash • Type of impact or collision • Speed of vehicles Understanding the events of the crash can help in determining the interventions necessary. For example, frequent crashes due to over speeding of vehicles or due to lack of mid-block crossings, both involve pedestrians however require different types of interventions. Similarly crashes with cyclists could be in due to different scenarios that could be due to narrow bike lanes, shared streets, or even lack of adequate buffers between the lanes. Higher frequency of a scenario would determine the necessary safety measures that have to be undertaken.
CRASH LOCATION (GEO-CODED)	Maintaining records of crash location over a period, will help identify black-spots and critical areas within the city. Higher the number of occurrences in an area would mean higher priority and a greater scope of implementing improvements. Geo-coding crash location eases the data processing and interpretation using GIS software. Also, this helps in linking different variables, that may be collected from various sources, to the single incident and reduce duplication of data. These records also help determining the surrounding environments in which the crashes have happened. Different urban contexts i.e. intense urban to suburban, require different levels of interventions. The decision-making processes and the choices of interventions vary based on the context. High occurrences of crashes in an intense urban environment such as a Central Business District (CBD) may require re-routing of vehicles and identifying an area as pedestrian only. On the other hand, a similar situation in a suburban area may be mitigated by introducing road diets and speed reduction techniques such as speed tables.

Ⓑ ROAD CRASH DATA COLLECTION

Road crash data can be sourced from multiple agencies. However, each have their own challenges and limitations. The Road Safety Manual developed by PIARC ascertains that any single crash-injury database does not provide adequate information to give a holistic picture of road traffic injuries. Many countries have therefore started using both crash data collected by the police along with the health sector data.

DATA SOURCES

POLICE RECORDS

As the police are often the first to be informed of a crash, police reported data is the hence the primary source for crash data. A standard template report is created for each incident; the contents of which, will differ from country to country. Most reports will contain, at the very least, date & time of crash, location, vehicles involved and number of injuries & fatalities. In addition, the crash description may contain information about how the crash occurred, as inferred by the reporting officer, and as described by the involved parties and eyewitnesses. Some cities also mandate the inclusion of a crash diagram. Precinct-level data is then rolled-up and aggregated by the central police department, which is usually what is made available publicly. Some information tends to get omitted during this aggregation process, which may be important for analysis.

While this is the major source for many jurisdictions, it however, isn't always the most accurate information – primarily due to human errors in the process of collecting and recording the data. One of the major challenges in acquiring accurate data is often attributed to discrepancies in definitions of the variables or the absence of the same. Also, only major crashes that cause serious injuries or fatalities or involve more vehicles get reported to the police. Minor crashes are often under-reported and thus do not always get included in this primary crash data source.

It is therefore recommended to complement police data with other secondary data sources.

HOSPITAL RECORDS:

This information is normally aggregated by the City Municipal Health Department. Hospital data is particularly useful in cases where there isn't adequate follow-up by the Police to update their own records, when a road crash victim is initially reported as injured, but may have subsequently died after the police report was filed. Also, in some cases, a police report does not get filed, perhaps because the involved parties were unwilling, or unaware, or cajoled into not filing a police report.

VEHICLE INSURANCE RECORDS:

A third source for traffic crash data is vehicle insurance providers. Like with hospital data, this is a useful source to supplement police records, in cases where a police report was not filed. Insurance records tend to provide a more comprehensive description of vehicle damage information, which is useful in understanding the causes of the crash.

The variables collected as part of crash data should not be analyzed individually. As the examples discussed above, the differences in variables can determine the nest steps for addressing the concerns. In case during assessment it is noted that the variables in the crash data aren't robust enough, then steps must be taken by the concerned authorities to further strengthen the data at the source. Some steps in may be undertaken in this regard are:

1. Inclusion of variables in the primary survey and database
2. Having clarity in definition of variables
3. Ensuring proper recording of variables in a digital format
4. Capacity building of police officers and agencies in recording of data

C DATA ANALYSIS

Based on the types of variables collected and its quality of detail, three different types of analyses may be undertaken, as explained:

BASIC TREND ANALYSIS

This analysis helps determine the important trends in traffic crashes in the city. It helps identify the most vulnerable modes, as determined by percentage share among crash victims. This data can also be relatively weighed against data on traffic mode share or vehicle-kilometers traveled, to get a more accurate description of crash risk for each mode group.

DATA REPRESENTATION	RELEVANCE TO TOD ASSESSMENT	INFORMATION REQUIRED
Tables, graphs (pie-charts, bar-diagrams, line graphs)	This analysis helps determine risk vulnerability of transit commuters, either on transit, or while accessing transit and is useful in identifying temporal trends (spikes or drops) in the data during a particular time of the day or year. This is relevant for TOD assessment, if the high-risk time periods correspond to the peak commuting hours.	• Date & time of crash • Characteristics of person(s) involved • Characteristics of vehicles & modes involved • Number of serious injuries and fatalities • Location of crash The data is recorded at the crash-level and corresponds to one unique crash. It is important to procure data normally between 5 and 10 years. Aggregated data is normally adequate for this analysis.

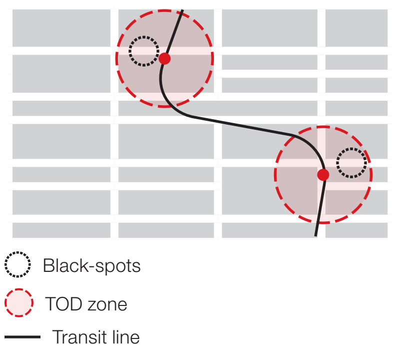
CRASH FACTOR ANALYSIS

A crash-factor analysis is useful in understanding the underlying causes of traffic crashes. When conducted on a large number of cases, it provides enough data to determine trends and identify dominant crash factors (causes). Traffic crashes are a multi-factor, random event, and most crashes cannot be attributed to a single cause. It is a combination of different factors that contribute to the occurrence and severity of the crash, including human, vehicle and road infrastructure factors.

<table>
<tr><th>DATA REPRESENTATION</th><th>RELEVANCE TO TOD ASSESSMENT</th><th>INFORMATION REQUIRED</th></tr>
<tr><td>Haddon Matrix
<table>
<tr><th></th><th>Human Factors</th><th>Vehicle Factors</th><th>Road Factors</th></tr>
<tr><td>Pre-crash</td><td></td><td></td><td></td></tr>
<tr><td>During crash</td><td></td><td></td><td></td></tr>
<tr><td>Post-crash</td><td></td><td></td><td></td></tr>
</table>
The Haddon Matrix is a two-dimensional model which is commonly used to approach safety analysis at a site in a systematic fashion. It is completed through the evaluation of site and crash details, and applies basic principles of public health to motor vehicle-related injuries.</td>
<td>Such an analysis is costly and time-consuming, and not essential for the broad assessment of TOD-readiness of the city. Its utility comes into play during the assessment of TOD infrastructure at the planning and design stage.</td>
<td>It is often observed that the cause is often identified as an error on the part of the driver of the vehicle(s) involved. Moreover, only one factor is reported as “causing” the crash, and doesn’t take into consideration the multi-factorial nature of road crashes. For a crash factor analysis, it is important to analyze the detailed crash report recorded at the police precinct level, and not just rely on the aggregated dataset.
Data collected includes various non-behavioral factors, such as:
• Road design (part of a detailed road inventory)
• Characteristics of the vehicle(s) involved including vehicle failure
• Crash type</td></tr>
</table>

BLACKSPOT IDENTIFICATION

This analysis is useful in identifying black-spots; that is locations with a high crash risk, as determined by a high crash frequency. Crashes are classified into mid-block and intersection locations. Depending on the city density, crash locations within 50 to 150 meters of each other may be clubbed together as one spot. Usually, a frequency of major crashes (with fatality or serious injury) of more than 3 occurrences in 1 year is considered grounds for inclusion as a blackspot. However, this rule may differ from city to city, depending upon overall crash frequency.

DATA REPRESENTATION	RELEVANCE TO TOD ASSESSMENT	INFORMATION REQUIRED
Thematic Map with transit alignment 	This analysis is useful for TOD assessment as it helps to identify high priority locations within the TOD commuting zones. When black-spots are further categorized by mode type, it helps to determine the crash risk for the main access mode to transit.	Black-spots are locations with high crash risk, as determined by high crash occurrences. This analysis requires: • Geo-coded location of each crash recorded as accurately as possible • Date and time of crash • Characteristics of person(s) involved • Crash severity Location information is particularly important in identifying priority areas for intervention and course correction. For instance, this analysis will help determine if there are any black-spots near an existing or planned transit corridor, which will affect the safety of access for transit commuters.

D CRASH CONFLICT ANALYSIS

Sometimes traffic crash data is inadequate in determining crash risk. At the site level, if there are not enough data points, then it is difficult to determine the extent of crash risk, or identify the key safety issues. A road safety inspection, to some extent, addresses this issue, as it relies on a qualified road safety expert to make this assessment. However, this may not always be a reliable strategy, because, sometimes, the occurrence of an issue is random, and may not take place during the time of the inspection.

A crash conflict analysis is one such measure to overcome the limitations of insufficient crash data. It involves a classified count of all incidents that could potentially lead to a crash during a given period of time. These incidents can be called near-misses; that is, situations that almost caused a crash. A near-miss includes incidents where the travel paths of two road users (vehicle-vehicle or vehicle-pedestrian) cross each other in a very brief fraction of time. It can also include the count of incidents where a road user undertook some form of evasive action to avoid a crash, such as abruptly braking or changing lanes at the last second; or suddenly darting across the street, (in the case of pedestrians).

Crash-conflict counts, today, are almost always, carried out with the aid of video cameras. These surveys have been gradually moving to automated systems in recent years, carried out with the aid of video cameras. The data is then fed into a computer program that is capable, through sophisticated algorithms, of automatically classifying vehicles, determining vehicular speeds, identifying intersection of travel paths, and identifying evasive actions by road-users.

The frequency of near-miss occurrences is then converted into a crash-risk frequency using predetermined coefficients of crash risk. These coefficients have been established over many years of scientific study of the correlation between crash-conflict risk situations and actual crash occurrences.

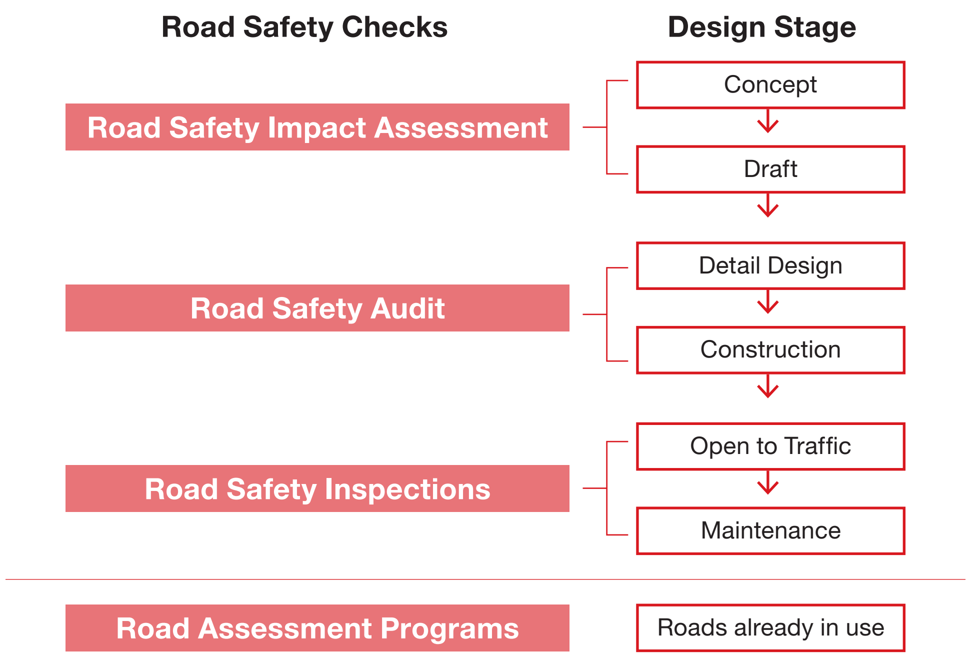
A crash-conflict study is useful in assessing crash risk on major nodes in the TOD zone. Normally, crash risk is the highest at major intersections, which is also, typically, the location where traffic video surveillance data is most easily available. This is, thus, a useful measure in determining site-specific crash-risk mitigation strategies.

E ROAD SAFETY ENGINEERING TOOLS

There are four road safety checking tools -

1. Road Safety Impact Assessments or RSIA
2. Road Safety Audits or RSA
3. Road Safety Inspections or RSI
4. Different road assessment programs such iRAP

The different road assessment programs are typically used to assess roads that are already in use and are an extension to the concept of RSA and RSI. They help estimating the risks for different street sections based on the road and roadside characteristics in the given context. While they may seem to be like each other, however they differ in their application and project cycle. The main distinction is in the timing and scope of the tools, as shown below.



As discussed earlier, these tools are applicable for all types of contexts and road types and help in determining the quality of the existing physical road infrastructure by identifying potential threats that may cause severe or fatal crashes in the future. However, for the purpose of road safety assessment for TOD readiness, their algorithms and considerations for assessments need to be modified for assessing roads and road network in a TOD. The roads and road networks with the TOD areas, need to be analyzed specific to the principles of TOD and the local socio-cultural contexts and need to be within an overarching framework designed specifically for requirements within a TOD, aligned with the Dutch '*Sustainability Safety'* vision design principles. Based on this assessment, any future planning and design interventions may be determined along with implementation strategies.

The modifications of these tools should be made in such a manner that they are able to identify weaknesses in the network based on the principles of safety in a TOD and are able to provide solutions that would help in mitigating them. To begin with, the tools need to ascertain the functions within the street – whether it has a mix of transit in its ROW or a mix of vehicular and NMT modes, if it caters towards accessing a transit station, or connects to various activity generator areas in the network or is a local neighborhood street. This mix of functions would therefore help in determining the future impact to the area and carry out required inspections. It will also help in ascertaining the kinds of users that may be allowed to commute on certain streets which may thus require redistributing the ROW to segregate the modes depending on the volumes of users that may be using it. While it is easier to determine the behavior of users for mono-functional roads; the multi-functionality of roads in TOD require adequate measures to minimize conflicts. The tools modified for a TOD assessment will help identifying these conflict areas and provide design solutions so that users are able to recognize their allocated spaces within the ROW and behave accordingly.

E ROAD SAFETY ENGINEERING TOOLS

ROAD SAFETY IMPACT ASSESSMENTS OR RSIA

It is a strategic comparative analysis of impact between different possible schemes of a new road design or any modifications to an existing network, to ensure the scheme is selected that has the best outcome for road safety for all users in the TOD area. This is carried out at the initial planning stage before detailed planning begins and helps in the decision-making process.

Road safety impact assessment highlights the road safety considerations and provides information for a cost-benefit analysis of different options or proposals that are based on the network planning principles for a TOD area and design safety design guidelines, along with the existing 'business as usual' scenario, which allows to compare the impact of the proposals on the safety performances for all road users. The RSIA typically has five main steps:

1. **Establish the baseline situation (year zero)** which measures existing traffic volumes, crashes per road type, risks, and other local conditions including topography, activity centers, weather conditions etc.
2. **Determine the future situation without any implemented measures ("Do Nothing" scenario)** that anticipates the impact by taking into considerations the current conditions and accounts for a future traffic growth.
3. **Determine the future situation under each scheme** for all road user by considering effect of the scheme per road type and function with respect to accessing station, orientations and movement of users within the larger road network in the TOD area.
4. **Perform Cost-benefit analysis for each alternative** and rank them by their individual effectiveness within the TOD.
5. **Optimize the plans for each scheme** to achieve optimal safety effect and best cost-benefit rating.

ROAD SAFETY AUDITS OR RSA

This is a formal detailed systematic and technical safety check performed to check that the selected scheme is designed and constructed in such a way as to yield the greatest road safety benefits, and to detect any potential hazards throughout all stages from planning to early operation. Usually a list of potential safety deficiencies and recommendations for improvement are included in the audit report.

The RSA process aims to identify and address any road safety issues under all operating conditions for all road users. It however does not check against design standards. As a cost-effective tool for identifying potential safety issues, it is typically undertaken at the earlier stages in order to adjust the design plans versus retrofitting features after implementation of the project. The European Union Directive on road infrastructure safety management states that such audits should be conducted at the draft design, detailed design, pre opening and early operation stages.

The RSA must be carried out by a skilled audit team with members having necessary skills and training to carry out road safety audit and must be independent of the design team and form the contractors. The auditors should also be aware of the local context and concepts of TOD and planning of road network with the station area. Certain countries have developed training for these purposes and maintain a list of qualified auditors. They have also prepared a checklists and guides for conducting audits (that may be adapted depending on the local contexts and specialized audits such as for a TOD area) to ensure key issues are considered during the process. More proactive audits have recently been developed based on the safe systems approach. These adopt a more holistic view of the issues and pay attention to reduction of fatal and serious crashes.

ROAD SAFETY INSPECTIONS OR RSI

These are periodical on-site review of the characteristics and defects, undertaken as part of an inspection of an existing road, or through maintenance procedures to detect potential crash risks. It is an independent, comprehensive and systematic assessment of an existing road by a qualified road safety expert, to identify locations or situations with the potential for crash risk, as well as to determine countermeasures to mitigate this risk. This crash risk within the TOD area is determined by the road safety expert's perception of both the likely frequency of such an occurrence, as well as the likely severity of injury and damage if it happens. As the identification of each issue is accompanied by its corresponding countermeasure catered to conditions and requirements of a

TOD, it provides the city authority and the implementing agency with a clearly understandable road map of on-ground interventions. These measures can then be taken to the design team, where the design specifications can be developed based on the network planning principles and design guidelines for safety measures in a TOD. It must however be noted that an RSI is not equivalent to a periodical maintenance check. It however helps in identifying safety issues that are resulting from improper maintenance practices such as deteriorating surfaces, poor traffic signs, unclear line markings, inadequate street lighting etc.

The inspection may be carried out for the entire network or for specific segments that are considered at higher risks. These may then be prioritized using previous crash data. Crash data is however not required to conduct the actual inspection. A road safety inspection is particularly useful in assessing the trunk routes to the transit station, within the TOD zone. These routes warrant the additional attention, as they are expected to carry the bulk of commuters to and from transit.

ROAD ASSESSMENT PROGRAMS

These are typically undertaken on existing roads, these quantify the expected safety outcomes for a network, route or location. These are ‘surrogate’ measures, programmed to determine crash risk and priority locations.

The global umbrella organization known as iRAP, which stands for International Roads Assessment Programme (www.irap.org), has developed measures for Star Rating of road infrastructure based on crash risk assessment. Star Ratings are based on observation data that is usually captured by a video recorder mounted on top of a vehicle and driven along the road. Various aspects of road infrastructure are captured through this process, such as the presence of median dividers, footpaths, pedestrian crossings, speed humps, lane markings, etc. This data is then fed into a central database, where it is interpreted to determine crash-risk. The lower the safety risk for a particular road, the higher is its star rating. The star rating can be generated for different modes separately, such as for pedestrians, cyclists and motorists.

The iRAP Star Ratings tool is helpful in generating large volume of crash risk data for assessing roads within a TOD zone. Since the tool generates crash-risk by mode, it can be used to assess safety risk for access modes to transit. It can, thus, be used to determine priority areas of intervention for road safety improvement in the TOD zone. Moreover, the iRAP tool allows the user to see how the Star Rating for a road can be improved by adopting different interventions. It allows the user to determine the most appropriate combination of interventions to minimize risk and improve safety assessment.

E ROAD SAFETY ENGINEERING TOOLS

TIANJIN URBAN TRANSPORT IMPROVEMENT PROJECT, TIANJIN CHINA

The Tianjin Urban Transport Improvement Project is a World Bank funded project. The aim of the project is to prioritize and enhance the non-motorized transport systems – walking and cycling with respect the public transportation system to create "safe, clean, and affordable accessibility and mobility solutions" for the city. It consists of four components:

1. NMT Improvement in the Heping and Nankai Districts
2. Access Improvement to the Mass Transit System
3. Public Bicycle Sharing System Demonstration Project
4. Bus Terminals

Baseline assessment studies were carried out for the first two components using ChinaRAP assessment tool to evaluate section of existing roads around transit stations within the two districts. This assessment was carried out for all road users: Vehicle occupants, Pedestrians and Cyclists. The assessment for Motorcyclists wasn't carried out as use of motorcycles is not allowed within the city limits.

The first component of NMT improvements aims at redevelopment of approximately 50 km of streetscape, covering 7.2 sqkm area, following the complete streets approach – re-prioritizing the street layouts to give more focus to the supporting biking and walking environments with respect to the public transport network especially metro lines. This will help reduce road safety hazards and challenges for the NMT network and all vulnerable users. Various types of improvements include:

1. **Street Pavement Updates and Drainage Improvement** which will involve lane redistribution and repaving of the ROW to include travel lanes, cycle and pedestrian infrastructure.
2. **Street Facilities** including lane markings, signage, on streetcar parking, bike parking, traffic signals, bicycle lane guide-rails, sidewalk bollards, pedestrian safety islands, bus stop sheds, and street lights.
3. **Landscapes Improvement** including street trees, installation of street furniture, and other landscape features.

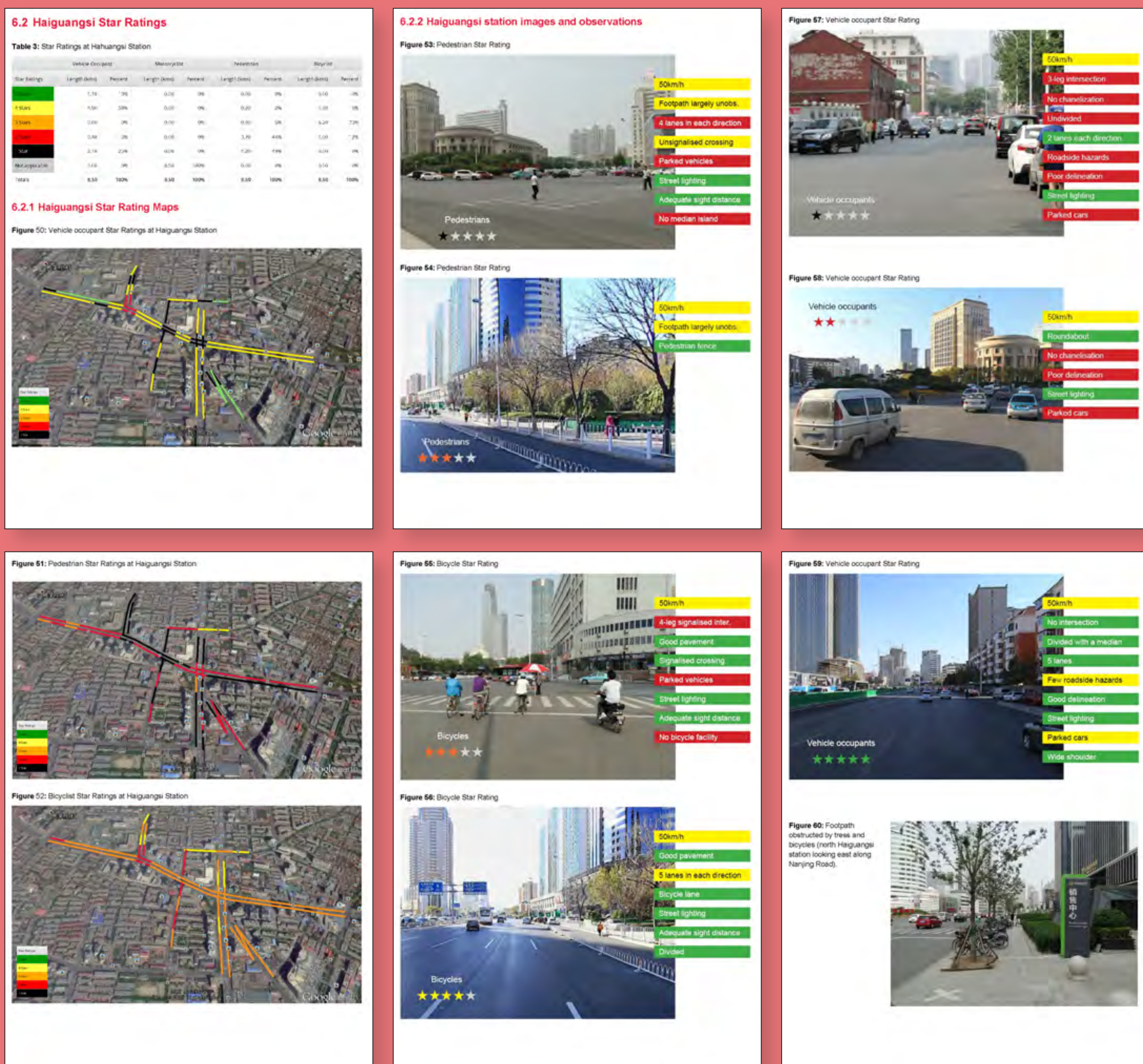
The second component of the project evaluates streets leading to the various transit stations in the Heping and Nankai districts to increase and improve the catchment area to better support the transit system. Based on the existing land use, demand and availability of the spaces around the transit station various measures have been proposed. The transit stations have been typically categorized into four types:

1. **'Transport Connection Stations'** that are located near planned bus terminals and car parking lots. The access improvements aim to improve the connections and transfers among different transport modes.
2. **'Park Vitality Improvement Stations'** which are located close to parks, and the types of improvements aim at enhancing the parks, pedestrian environment connecting to those parks, and connection to other transport modes.
3. **'Green Belt Vitality Improvement Stations'** are stations whose entrances are located near small landscaped or green areas. The intervention is to improve the environment surrounding the stations to enhance the attraction of Metro system.
4. **'Other Stations'** have limited space surrounding them. Improvements aim to promote transfers with bikes and other transport modes.

E ROAD SAFETY ENGINEERING TOOLS

Below is a snapshot of a typical star rating assessment carried out within the project area. Based on these assessment findings, different levels of improvements were suggested using the safe systems approach. These included:

- Reduction in vehicle speed
- Redistribution of space within the row to accommodate infrastructure and facilities for NMT needs including sidewalks, redesign, safer cycling services, local shared streets and public transport facilities including bus stops, vehicle parking
- Pedestrian crossings at intersections and mid-block, intersection design



Pages extracted from *"Baseline ChinaRAP Assessment of Roads in Tianjin (2015)"* showing star-rating of roads for all users around the Haiguangsi Station in Tianjin, China

REFERENCES

Austroads. 2012. Effectiveness of Road Safety Engineering Treatments, AP-R422-12, Austroads, Sydney, Australia

Cambridge Systematics Inc. 2010. *Highway Safety Improvement Program Manual.* Federal Highway Administration U.S. Department of Transportation. Washington DC

European Parliament, Council of the European Union. 2008. *Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on road infrastructure safety management*

Global Road Safety Partnership. 2008. *Speed management: A Road Safety Manual for Decision-makers and Practitioners*. Geneva.

International Transport Forum. 2018. *Road Safety Annual Report*

Speed management: a road safety manual for decision-makers and practitioners (Global Road Safety Partnership 2008)

World Resource Institute and World Bank Group. 2015. *Corridor Level Transit-Oriented Development Course*. Washington, DC

World Resources Institute and Global Road Safety Facility. 2018. *Sustainable & Safe : A Vision and Guidance for Zero Road Deaths.* Washington, DC: World Resources Institute