Vehicle Speeds and the iRAP Protocols

Policy Position
About iRAP

The International Road Assessment Programme (iRAP) is a not-for-profit organisation dedicated to saving lives through safer roads.

iRAP works in partnership with government and non-government organisations to:

- inspect high-risk roads and develop Star Ratings and Safer Roads Investment Plans
- provide training, technology and support that will build and sustain national, regional and local capability
- track road safety performance so that funding agencies can assess the benefits of their investments.

Road Assessment Programmes (RAP) are now active in more than 50 countries throughout Europe, Asia Pacific, North, Central and South America and Africa.

iRAP is financially supported by the FIA Foundation for the Automobile and Society. Projects receive support from the World Bank Global Road Safety Facility, automobile associations, regional development banks and donors.

National governments, automobile clubs and associations, charities, the motor industry and institutions such as the European Commission also support RAPs in the developed world and encourage the transfer of research and technology to iRAP. In addition, many individuals donate their time and expertise to support iRAP.

For more information

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To find out more about the programme, visit www.irap.org. You can also subscribe to ‘WrapUp’, the iRAP e-newsletter, by sending a message to icanhelp@irap.org.

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1 Introduction

Vehicle speed influences both the likelihood of a crash occurring and its severity. Speed is therefore a critical aspect of managing a safe road system, and influences iRAP’s Road Protection Scores, (RPS), Star Ratings and Safer Roads Investment Plans.¹ In essence, the safety of a road cannot be understood without the knowledge of the traffic speeds.

2 Speed Management Overview

Speed management is a complex area of policy for any country. The setting and enforcement of speed limits compatible with the road use at a location is an essential component of a safe road system. Roads should be engineered to reflect the road use and desired speed environment. This involves political leadership, community engagement, enforcement and engineering to achieve the best outcomes.

iRAP assessments typically focus on the high risk sections of the road network where the risk of fatalities and serious injuries is greatest. This primarily includes higher speed rural roads and urban arterials, and roads where vulnerable road users are not adequately provided for. The iRAP models and theory therefore focus on the influence of speed in these environments.

iRAP models recognise the important role of speed in understanding the safety of a road. Vehicle speeds play a major role in the likelihood of a crash and in the severity of a crash. This paper outlines iRAP’s policy in relation to speed.

3 Speed and Safety

Excessive and inappropriate speed is the number one road safety problem in many countries, often contributing to as much as one third of fatal accidents and an aggravating factor in all accidents (OECD, 2006).

Speed has been identified as a key risk factor in road traffic injuries. Higher speeds lead to a greater risk of a crash and a greater probability of serious injury if one occurs.

This is because, as speed increases, so does the distance travelled during the driver’s reaction time and the distance needed to stop. Also, at speed, the effects of failing to anticipate oncoming hazards in good time and of vehicle handling errors are magnified. In addition higher speeds can cause others to misjudge closing speed. Most research now provides clear evidence of the relationship between higher vehicle speeds and crash involvement (Baruya, 1998; Bowie and Walz, 1993, 1994; Fildes et al, 1991; Taylor et al, 2000).

¹ Risk Mapping and Performance Tracking implicitly include operating speed through their use of actual crash data. These two protocols are not addressed specifically in this policy.
The relationship between travel speed and injury severity is even more strongly demonstrated by the research (Elvik, Christensen and Amundsen, 2004; Kloeden et al, 1997; Nilsson, 1984 and 2004). The probability of injury, and the severity of injuries that occur in a crash increases, not linearly, but exponentially with vehicle speed – by a factor of four for fatalities, three for serious injuries, and two for casualty crashes. Even small increases in travel and impact speed results in a great increase in the forces experienced by vehicle occupants and other road users.

It is useful for road traffic injury prevention researchers and practitioners to understand the biomechanics of kinetic energy injuries. This will help them develop measures that will limit the generation, distribution, transfer and effect of this energy during a road traffic collision (Haddon, 1973).

The kinetic energy to be absorbed in a crash equals one half of mass multiplied by the square of velocity – illustrating that the effect of velocity is greatly enhanced as velocity increases. The level of damage to the body will depend on the shape and rigidity of the colliding surface or object, but velocity usually plays the most critical role (Christoffel and Gallagher, 2006).

Vulnerable road users such as pedestrians, cyclists, moped riders and motorcyclists have a high risk of severe or fatal injury when motor vehicles collide with them. This is because they are often completely unprotected or, in the case of a motorcyclist, have very limited protection. The probability that a pedestrian will be killed if hit by a motor vehicle increases dramatically with speed. In Figure 1 the probability of a fatal injury for a pedestrian colliding with a vehicle is illustrated (GRSP, 2008). The research indicates that while most vulnerable (unprotected) road users survive if hit by a car travelling 30 km/h, the majority are killed if hit by a car travelling at 50 km/h (OECD, 2006).

For car occupants, wearing seat-belts and using well-designed cars generally can provide protection to a maximum of 70 km/h in frontal impacts, and 50 km/h in most side impacts (Tingvall and Haworth, 1999). While recent analysis by Richards and Cuerden (2009) is generally supportive of this estimate and the Wramborg (2005) assessment of crash risk for head on and side impact crashes, it indicates that the risk of fatality may in fact be greater than Wramborg’s predictions.

Higher speeds could be tolerated if the interface between the road infrastructure and vehicle were well designed and not likely to result in a fatal outcome if there is driver error. A simple example would be the provision of crash cushions to protect bridge abutments or similar hazards.

However, most road systems allow much higher speeds without adequate protective measures such as barriers between vehicles and between vehicles and roadside objects.

The likelihood of a fatal crash outcome for run off road hit fixed object crashes where the side of the vehicle impacts a sharp object such as a tree or pole, is substantial for travel speeds greater than 60 km/h. For this reason, removal of road side objects or installation of protective barriers is necessary on higher speed rural roads.
Figure 1  Probability of fatal injury for a pedestrian colliding with a vehicle (Tingvall and Haworth, 1999)

![Figure 1](image1.png)

Figure 2  Probability of fatal injury for a vehicle occupant in a side impact (on side of vehicle impacted) and head on crash (front seat) (derived from Wramborg, 2005)

![Figure 2](image2.png)
4 Small Increases in Speed

Small percentage increases in speed lead to much greater percentage increases in fatalities. Figure 3 indicates the increase in crashes of varying severity for small increase in travel speed.

Figure 3 Illustration of the Power model and the relationship between % change in speed and the % change in accidents (Nilsson, 2004)

![Graph showing the relationship between change in mean speed and change in accidents.]

Relatively small mean speed reductions lead to major fatal (and to a lesser extent, other injury) crash reductions. Many experienced drivers are surprised when made aware of the serious casualty crash reductions available through small mean traffic speed reductions. Table 1 indicates the potential reductions in fatal crashes when mean speeds reduce (Aarts and van Schagen, 2006).

Table 1 Application of the Power model for different reference speeds when the average speed is reduced by 2 km/h

<table>
<thead>
<tr>
<th>Crash type</th>
<th>Reference speed in km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td>All injury crashes</td>
<td>7.8</td>
</tr>
<tr>
<td>Fatal and serious crashes</td>
<td>11.5</td>
</tr>
<tr>
<td>Fatal crashes</td>
<td>15.1</td>
</tr>
</tbody>
</table>

Research by Kloeden et al (1997) shows that:

- travelling at speeds just 5km/h above a speed limit of 60km/h in urban areas and 10km/h above a speed limit of 100 km/h in rural areas – doubles the casualty crash risk
- this increase in risk is comparable to driving with a blood alcohol concentration of 0.05 g/100 ml compared to a zero level.

So, higher travel speeds increase crash risk and “moderate” speeding (within 10 or 15 km/h of the posted limit) makes a large contribution to serious road crashes – comparable to the contribution of more extreme speeds - because it is so common (see Annex A – Case Studies: Speed and Fatalities).
5 The Importance of Speed Limits

Speed limits are most important in determining the relative crash risk road users will be subjected to on a length of road. Frith et al (2003) and Oxley (2006) state:

“They are considered to be the most powerful road feature that determine the speed at which drivers and riders choose to travel and therefore play a pivotal role in determining overall crash and injury risk. Many studies world-wide have examined the effect of raising or lowering speed limits in both rural and urban environments and consistently show that crash incidence and injury severity decline whenever speed limits have been reduced (Finch et al. 1994; Frith & Toomath 1982; Haworth et al. 2001; Newstead & Mullan 1996; Nilsson 1990; Diamantopoulou & Corben 2001; Sliogeris 1992).

Conversely, studies consistently show that the number of crashes and injury severity increase when speed limits are raised, especially on freeways (Cameron, 2004; Johnston, 2004; Newstead & Mullan, 1996; Newstead and Narayan, 2001; NHTSA, 1989; Parker, 1997; Patterson et al, 2002; Richter et al, 2004; Sliogeris 1992; and TRB, 1998). Speed limit selection is a critical indicator to road users of the safe speed for that section of road in ideal conditions.

iRAP recognise that the setting of speed limits is a complex area of policy and analysis in any country and will typically consider the desired travel speed at the location relative to the road users, function, geometric design and abutting development characteristics of the road.

6 Safe System and the Role of Speed

Vehicle speeds are a critical element in understanding the safety of a road and the provision of a safe system. Key issues to consider include:

- Speed limit reductions alone will only lead to small reductions in travel speeds. Effective enforcement strategies are crucial.
- Worldwide, to prevent road death and disabling injury, a traffic system better adapted to the physical vulnerabilities of its users needs to be created – with the use of more crash-protective vehicles and roadsides.
- The Safe-system approach, as exemplified by Vision zero (Sweden), Sustainable safety (Netherlands) and Safe system (Australia) should set the framework for the long-term management of speeds on a nation’s roads.
- Adopting a Safe-system approach is being considered by a number of jurisdictions globally. This approach is likely to be based on the following or similar speed environments:
  - a 30 km/h speed limit being used in built-up areas where there is a mix of vulnerable road users and motor vehicle traffic
  - restricting approach speed limits to less than 50 km/h to reduce the likelihood of fatal side-impact crashes at intersections (it is often preferable to build a roundabout instead of installing traffic lights)
restricting speed limits on two way single carriageway roads below 70 km/h, or installing median barriers to reduce the likelihood of fatalities from head-on crashes.

Safe-system thinking can contribute to the immediate needs of low and middle-income countries and, as for all countries, to more rapid, long-term road safety improvement. The Safe-system approach requires system managers to understand the key risk factors that contribute to crashes in order to assess crash risk.

7 Speed Measurement Options

For the purpose of iRAP studies there are three main speed measures that are recorded. This allows for a more detailed interpretation and analysis of issues relating to speed in the iRAP assessments and models. The measures include the speed limit, mean speed and 85th percentile speed (as defined below). The iRAP Inspection Manual provides detailed guidance on these features.

1. Speed limit: the sign-posted legal speed limit or, where no speed limit signs are posted, the speed limit that applies as a matter of law.  
2. Mean speed: The average speed of vehicles past a nominated point.
3. 85th percentile speed: The speed at or below which 85% of all vehicles are observed to travel under free flowing conditions (typically > 4 sec headway between vehicles) past a nominated point. Historically the 85th percentile speed has been a key attribute used in the setting of speed limits.

Measurement of actual speeds (particularly on higher risk lengths of the network) is considered an essential part of an iRAP project. This data can be used to calculate mean speeds and 85th percentile speed and provide a valuable source of information to help guide any debate on speed management needs (refer to Annex B for speed measurement options.

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2 Initial iRAP analyses undertaken prior to 2010 have been based primarily on speed limit.
3 Signed speeds that are merely advisory and, therefore, are not legally enforceable are not treated as speed limits. However, advisory speeds signed in advance of specific road features are considered in iRAP’s rating categories for quality of curve, quality of intersection, and quality of crossing.
4 It is noted that various options exist to categorise actual vehicle travel speeds. This may include measurements such as the mean speed, 85th percentile speed, 15 or 20km/h pace speeds, average speed and free-flow speed. iRAP will continue to encourage and monitor research in this area.
8 iRAP Speed Policy

The iRAP speed policy outlines the appropriate speed measure to be used for the various components of the iRAP protocols including star ratings, investment plans and economic analysis.

8.1 Road Protection Scores & Star Ratings (operating speed)

The iRAP Road Protection Scores (RPS) and Star Ratings are based on the vehicle operating speeds. For the purpose of iRAP assessments operating speed on a road or section of road is defined as being the greater of the following:

- speed limit
- 85\textsuperscript{th} percentile speed, rounded to the nearest 5km/h or 5mph as used in the jurisdiction.

iRAP studies will include an appropriate sampling and measurement of actual speeds where funds permit. Where 85\textsuperscript{th} percentile speed data is not available, the speed limit shall be used.

8.1.1 Discussion and Limitations

Vehicle speeds vary throughout the day as a function of volume, traffic conditions, traffic flow, weather and other factors. As an example vehicle speeds may be significantly less than the speed limit during congested peak hour conditions, and significantly higher than the speed limit at night time and/or unconstrained times when there is no enforcement or compliance culture. Crash risk would therefore vary throughout the day. Limitations of current research and the limited availability of traffic volume, speed and crash distributions throughout the day limit the ability of the iRAP models to reflect this variation.

For the purpose of iRAP star rating assessments the use of operating speeds (as defined above) has been selected for the following reasons:

- the star rating will be based on at least the legal speed limit for the section of road, and
- where the 85\textsuperscript{th} percentile speed is greater than the speed limit, the star rating will reflect the safety provided to the majority of the traffic flow.
- casualty crash and higher severity outcomes are more likely when travel speeds are higher.

\footnote{A variety of speed measurement metrics are used worldwide including the 85\textsuperscript{th} percentile speed, upper limit of the 15 or 20km/h pace speeds (15km/h or 20km/h speed range that includes the greatest number of observations – or equivalent in mph), mean speed, average speed, free-flow speed. The 85\textsuperscript{th} percentile speed has been selected to align with the most commonly available speed measurement in use worldwide.}
Key limitations of the current approach include:

- some research studies relating traffic speed to crash risk do not always state the measure used for speed in the analysis (e.g. mean speed, 85\textsuperscript{th} percentile speed, free flow speed, pace speed).
- some research studies relate risk to mean speed and therefore the risk factors may provide a stronger relationship to mean speeds than 85\textsuperscript{th} percentile speed.
- where 85\textsuperscript{th} percentile speed is below the speed limit, the RPS and associated Star Rating would be based on the legal speed limit. This will represent the road as less safe than is experienced by the majority of road users, but will reflect the safety experienced by users travelling at the legal speed limit.
- Where 85\textsuperscript{th} percentile speed is above the speed limit, the RPS and associated Star Rating will be based on an illegal behaviour, but behaviour that is representative of what actually occurs at the site.

The iRAP Global Technical Committee has determined that these limitations are accepted at this stage to ensure the model balances the availability of data and research and ensures road standards are at least measured relevant to the legal speed limit at a location.

iRAP in-country teams are permitted and encouraged to undertake separate analysis of the effects of speed on RPS and Star Ratings as part of the sensitivity analysis of any project. These studies can then be used as part of any speed limit reviews within the country.

8.2 Countermeasure Triggers (operating speed)

The countermeasures triggered as part of an iRAP Safer Roads Investment Plan are based on operating speed. The iRAP Global Technical Committee has determined that the need for any countermeasures must be based on the actual operating conditions at the location.

Countries are encouraged to ensure that speed limits are appropriate and associated enforcement and education campaigns support user compliance. To be effective in achieving compliance with speed limits, enforcement and education strategies and actions need to be carefully planned, adequately resourced and fully supported by the highest levels of government.

8.2.1 Discussion and Limitations

The accepted limitation of this approach is that countermeasures may be triggered on roads based on illegal speeds where 85\textsuperscript{th} percentile speeds are greater than the speed limit. Actual casualties along a stretch of road will be linked to the actual on-road behaviours and treatments should therefore be based on these conditions.
Countries are encouraged to undertake a speed management review at locations where the 85th percentile speed is in excess of the speed limit. If any action taken (e.g. revised speed limits, enforcement action, community education) results in a change in the operating speed at the location then it is recommended that the site data (iRAP Data Input File6) is updated as necessary and any iRAP analysis re-run to reflect the changed operating speed after action has been taken. This will then ensure that countermeasures are triggered on the new behaviour at the location.

iRAP in-country teams are encouraged to undertake separate analysis of the effects of speed on Safer Roads Investment Plans as part of the sensitivity analysis of any project.

8.3 Casualty Estimates and Economic Benefits (mean speed)

The casualty estimates along a road section and the determination of economic benefits associated with an iRAP countermeasure are based on mean speed. The underlying research used in the iRAP model is based primarily on relationships between mean speed and crash risk.

The estimation of casualties and associated economic benefits is based on a multiplicative relationship between the full traffic volume and the associated speed risk factors (in addition to other attributes). As a result, the use of the risk factors for the average (or mean) speed provides the best estimate for actual casualties and economic benefits.

This approach captures the direct link between speed and fatal and serious injury crash outcomes. For example:

- On a road with significant congestion and mean speeds well below the speed limit, it can be expected that the serious injury crash rate will be less than on a road where traffic speeds are equal to or greater than the same speed limit.

- On a road with continuous poor horizontal alignment, the speeds will often be significantly less than the speed limit, and the actual mean speed provides the best indication of fatal and serious injury outcomes.

- On a road where mean speed is above the speed limit the actual number of casualties is expected to be higher than on a road where the speed limit is adhered to.

6 Refer to iRAP Star Rating and Investment Plan Quality Documents for further details – contact the iRAP Engineering Manager icanhelp@irap.org.
8.3.1 Discussion and Limitations

Where the mean speed is significantly less than the speed limit or 85th percentile speed at a location, the use of speed limit or 85th percentile would more than likely lead to an over-estimate of the fatal and serious injury outcomes at the location.

Limitations of this approach include:

- Fatal and serious injury crashes and outcomes may be more prevalent amongst traffic flow in the higher end of the speed profile (that is vehicles travelling at higher speeds).
- The use of mean speed does not provide an indication of the shape of the speed profile where in some cases relatively few vehicles may be travelling at significantly higher speeds and associated higher risk.

These limitations have been accepted by the Global Technical Committee. The majority of research data currently focuses on the relationship between crash risk and mean speed and as such should provide a relatively accurate representation of casualties. More detailed relationships that look at differential crash risk at different points of the speed profile related to proportions of the traffic flow at the site are not routinely available across all road conditions. Data availability will also limit the potential for practical application of this or similar approaches. Continued research in this area is encouraged.

Speed management at a location is also an important road safety countermeasure that should be considered as part of any countermeasure programme. The activation, implementation and success of speed management as a countermeasure is complex though and requires coordinated action across key agencies. The results of any speed management initiatives are therefore considered separately in an iRAP assessment, with further details provided in following sections.

8.4 iRAP Speed Policy in Practice

The following table provides a summary of the iRAP policy on speed in relation to RPS, Star Ratings and Safer Roads Investment Plans as approved by the iRAP Global Technical Committee.
### Table 2  iRAP Protocols and Speed

<table>
<thead>
<tr>
<th>iRAP Protocol</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road Protection Score</strong></td>
<td>The RPS shall be based on operating speed* and incorporate the impact of speed on both the likelihood and severity of a crash.</td>
</tr>
<tr>
<td><strong>Star Rating</strong></td>
<td>The Star Rating is based on the Road Protection Score and is therefore directly impacted by the operating speed* at the location. Where needed, references to the Star Rating at a location should include the operating speed at that location. For example: With traffic operating speeds of 70 km/h the road is rated as 3 star</td>
</tr>
<tr>
<td><strong>Safer Roads Investment Plan</strong></td>
<td></td>
</tr>
<tr>
<td>• Casualty Estimate</td>
<td>The casualty estimation is based on the full traffic volume at the site and the Road Protection Score attributes with the use of mean speed (and not operating speed as used for RPS and Star Ratings).</td>
</tr>
<tr>
<td>• Countermeasure Generation</td>
<td>Countermeasures are triggered on the operating speed at the location. That is treatments should be based on actual behaviours.</td>
</tr>
<tr>
<td>• Economic Analysis</td>
<td>All benefits (casualty reductions) will be based on the before and after casualty estimations based on the full traffic volume at the site and the mean speed of those vehicles. That is the benefits reflect the actual behaviours at the location.</td>
</tr>
</tbody>
</table>

* operating speed is defined as the greater of speed limit and 85th percentile speed rounded to the nearest 10km/h

iRAP in-country teams are permitted and encouraged to undertake separate analysis of the effects of speed on Road Protection Score, Star Rating and Safer Roads Investment Plans as part of the sensitivity analysis of any project. These sensitivity analyses should help inform locate debate on speed management and initiate action in this area if required.

iRAP teams may not possess the expertise across all areas of speed management. Partners are directed to the Road Safety Toolkit (www.irap.org/toolkit) and the United Nations Road Safety Collaboration Good Practice Guide on Speed Management and relevant experts in this area if required.
9 iRAP and Speed Management Countermeasures

Many countries are moving towards the “safe system” approach to managing road safety on their networks. Central to the safe system approach is speed management, and many authorities are preparing policy and decision making tools in this area.

Although at the early stages of development the data available from an iRAP study can play a major role in assisting with objective assessments of speed management initiatives. The iRAP data can also help identify where speed management initiatives have potential to save lives and reduce serious injuries.

The implementation of speed management initiatives may involve a range of treatments from engineering measures, enforcements options and community education. As a result it is recommended that iRAP studies produce a separate report focussed on speed management issues.

The analysis currently being considered for inclusion in these separate iRAP speed management reports is summarized below:

- Undertake the **Star Rating** of the network
- Develop the **Safer Roads Investment Plan** – based on an ambitious, yet affordable package of engineering improvements
- Prepare the “**predicted STAR RATING after network improvement**” map based on the condition of the network after implementation of all economically viable countermeasures.
- Calculate the “**crashes per kilometre**” in accordance with the iRAP Risk Mapping Protocol (preferably using local crash data where available, or using the fatality estimations from the Star Rating assessment if necessary). Identify those sections of road where the accident density (crashes/km) is classified as “high” risk and “medium-high” risk.
- The iRAP Safer Roads Investment Plan includes a recommended **speed management review** on all sections that have:
  - 85th percentile speeds in excess of the speed limit, OR
  - Crashes per kilometre are specified as either “high” risk or “high” and “medium-high” risk (user definable) in accordance with the Risk Mapping protocol detailed above, OR
  - Road sections that remain either 1 star OR 1 and 2 star (user definable) based on the “predicted STAR RATING after network improvement”.
- Calculate the **required operating speed** for the relevant sections to meet **minimum 2 star or 3 star standard** (user definable) as required by the in-country team. This may be related to individual road user groups if required (pedestrian, bicycle, motorcycle and car occupant).
- The **potential killed and serious injuries** (KSI’s) that could be saved through identified speed management initiatives can be reported. No attempt to report costs or benefit cost ratios will be possible as the cost to implement effective speed management will be unknown or highly variable.
iRAP projects and reports will include a summary discussion on speed management and the relationship between speed and infrastructure safety. All speed management countermeasures will be separately reported to authorities and subject to more detailed analysis and review. This reflects the complex nature of speed management from a policy and implementation perspective.

10  iRAP and Safe System Performance Indicators

There is also potential for iRAP to include a range of safety performance indicators (SPI’s) that can be used by authorities as they move towards a safe system. This area will be subject to further research and development during 2010 and 2011. Examples of these potential SPI’s are provided below:

- Percentage of vehicle kilometres travelled (vkt) on roads with operating speeds > 70km/h where head-on risk still exists.
- Percentage of vkt on roads with operating speeds > 70km/h where roadside hazards exist.
- Percentage of vkt on roads with operating speeds > 40km/h and high pedestrian demand with poor pedestrian provision.
- Percentage of intersections with operating speeds > 50 km/h which are not safe system compliant.
11 References


Annex A – Speed and Fatalities – Case Studies

- **New Zealand**: Research found that if average speed on rural roads was reduced by just 4km/h, fatalities would decrease by about 15% and injuries by 8% (Patterson et al, 2005).

- **USA**: Impacts of speed limit adjustments in the US.
  
  o Fatalities increased by some 35% in States which increased limits from 65 to 70-75 mph (1996), compared to those that did not.
  
  o Limits were increased in some States from 55 to 65 mph (1987/88). Average speeds increased by 3 mph. Fatalities increased by 20 – 25% (Patterson et al, 2002).
Annex B – Speed Measurement Procedures

The iRAP assessments require a good and consistent understanding of the actual speed behaviour of traffic on the roads surveyed. Ideally this will be sourced from existing records held by the road authority or enforcement agency and may include:

- Permanent speed and traffic counting sites, or weigh-in-motion sites.
- Specific speed surveys (7 day counts, 24 hour counts or similar local studies)
- Police enforcement data (particularly covert speed detection sites or fixed speed cameras or point to point speed monitoring systems)

Where this data is not available iRAP recommend the collection of small samples of speed data to help inform the iRAP assessments and analysis. The recommend procedure is outlined in the iRAP Quality Documents and practitioners should refer to the latest version of the procedure prior to undertaking any assessments (refer to iRAP Engineering Manager – icanhelp@irap.org). An example of the sampling techniques completed for the iRAP project in Paraguay (2010) is detailed below.

**Speed Measurement Procedures for iRAP Paraguay**

- Each site of the list has been assigned a site number, beginning with 501. Record this site number on the data form.
- For each site, choose a location to measure speeds that is level and tangent, if possible. The field crew may select any suitable location within the boundaries shown on the list of sites.
- For rural sites, choose a speed measurement location that is away from development and intersections.
- For urban or suburban sites, choose a speed measurement location that is well away from traffic signals; the location may be near driveways or minor intersections, but do not measure speeds of vehicles when another vehicle is turning.
- Document the speed measurement location and the roadway characteristics on the data form including, if possible, GPS coordinates (latitude and longitude). If GPS coordinates are not available, describe the location precisely (such as on Route 5 at 4 km west of a particular town intersection)
- Locate vehicles, personnel, and equipment in a concealed location that does not attract the attention of drivers or affect their speeds. Ideally, drivers should not know their speeds are being measured as they approach the speed measurement location.
- Measure speeds of 100 motor vehicles at each location and record the speeds on the data form provided. Do not record speeds for bicycles or other non-motorized vehicles.
• Measure speeds only for vehicles that are not being delayed by another vehicle. In other words, only measure speeds for vehicles that are by themselves or are leading a platoon of vehicles. Do not measure speeds for vehicles that are in a platoon behind other vehicles.

• Record speeds separately on the form separately for motorcycles and other vehicle types.

• Select vehicle to measure in an unbiased way, so that the vehicles selected are representative of the traffic stream. This can be accomplished as follows. As soon as the speed of one vehicle has been measured and recorded, measure the speed of the next eligible vehicle that comes along, regardless of what type of vehicle it is.

• At most sites, measure speeds for vehicle in only one direction of travel. The direction of travel for which vehicle speeds are measured should be recorded on the form as northbound, southbound, eastbound, or westbound. At sites with very low traffic volumes, speeds of vehicles may be measured for both directions of travel so that it will take less time to get speed data for 100 vehicles.

• At sites with very low traffic volumes, the collection of speed data may be ended after 4 hours, even if 100 vehicles have not yet been measured.

• Take of photograph of each site facing in the direction of travel for which speeds are measured. Include the site number in the file name for the photograph.