iRAP Safety Assessment of Golden Quadrilateral (Delhi-Mumbai and Mumbai-Chennai sections) – *Preliminary Results*

Around the world 1.25 million people die as a result of road traffic crashes each year, that's 3,420 deaths per day, or one every 25 seconds.[1] Although several high-income countries are reducing the number of deaths on their roads, many low and middle-income countries are experiencing an increase in the numbers of fatal and serious injuries. In India, over 150,000[2] people were killed in road crashes in year 2016 equating to 17 deaths every hour and it costs more than 3% of national GDP each and every year.

With an aim to reduce fatalities and injuries from road traffic crashes on the major highway network in India, the Global Road Safety Facility (GRSF), International Road Assessment Program (iRAP) and National Highway Authority of India (NHAI) conducted safety assessments on the Delhi-Mumbai and Mumbai-Chennai sections of Golden Quadrilateral (GQ). These two sections of GQ are among the most strategic set of corridors in India in terms of linking major cities, ports, and industries. The safety assessment has been conducted using iRAP Star Rating which is a systematic approach to identify deficiencies and improve safety infrastructure provisions across major road network.

The preliminary results of the assessment are shared with NHAI's Road Safety Cell. This Executive Summary presents the Star Rating results and Safer Roads Investment Plan (SRIP) prepared for Delhi-Mumbai and Mumbai-Chennai sections of GQ in brief.

Table 1 Road assessment of Delhi – Mumbai and Mumbai – Chennai sections of GQ in India

Name of Road	Centerline length	Carriageway length[3]
NH48 Delhi – Gurugram – Jaipur – Kishangarh	344.1 km	688.2 km
NH79 Kishangarh – Nasirabad – Chittorgarh	214 km	425.1 kn
NH76 Chittorgarh – Udiapur	110.4 km	210.1 km
NH48 Udaipur – Ahmedabad – Vadodara – Bharuch – Surat – Vapi – Mumbai	744.4 km	1471.4 km
Total length assessed on Delhi – Mumbai section of GQ	**1412.9 km**	**2794.8 km**
NH48 Mumbai – Pune – Satara – Kolhapur – Belagavi – Hubbali – Bengaluru	1016.9 km	1975.9km
NH44 Bengaluru – Krishnagiri	76 km	151.8km
NH48 Krishnagiri – Vellore – Chennai	254.5 km	508.9km
Total length assessed on Mumbai – Chennai section of GQ	**1347.4 km**	**2636.6km**
Total length assessed (both sections)	**2760.3 km**	**5431.4 km**

The two sections of GQ were assessed by iRAP to produce Star Ratings which are based on road infrastructure features and the degree to which they impact the likelihood and severity of road crashes. The focus is on the features which influence the most common and severe types of crash on roads for motor vehicles, motorcyclists, pedestrians and bicyclists. The infrastructure-related risk assessment involved detailed surveys to capture GPS stamped video images which were further analysed to get 50+ road attributes

[1] WHO Global status report on road safety (2015)
[2] Road Accidents in India – 2016. Transport Research Wing, Ministry of Road Transport and Highways, Govt. of India
[3] Length assessed is the total of both carriageways and hence approximately double of the road length.

at 100 metre intervals. The analysed data was processed using iRAP software ViDA to produce Star Ratings and Safer Roads Investment Plan (SRIP). The software and results can be accessed at http://vida.irap.org.

Table 2 Star Ratings for Delhi-Mumbai and Mumbai-Chennai sections of GQ (Speed Limit 80kmph)

	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent	Length (kms)	Percent
5 Stars	40	1%	0	0%	1	0%	0	0%
4 Stars	245	5%	9	0%	10	0%	0	0%
3 Stars	2981	55%	1174	22%	33	1%	14	0%
2 Stars	1881	35%	3010	55%	185	3%	562	10%
1 Star	229	4%	1184	22%	3401	63%	3363	62%
Not applicable	55	1%	55	1%	1801	33%	1492	27%
Totals	5431	100%	5431	100%	5431	100%	5431	100%

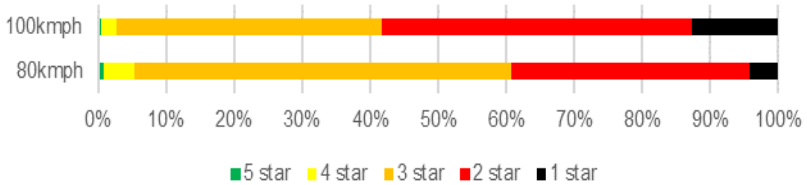
The supporting data like traffic volume (AADT), vehicle operating speeds and road crash data play an important role in preparing Star Ratings and SRIP. Traffic volume data for road sections of Delhi-Mumbai and Mumbai – Chennai sections of GQ were collected from NHAI's Toll Information System (TIS)[4]. The road crash data were collected from relevant Project Implementation Units (PIU) websites. The crash data available for each PIU vary timewise and for few road sections the data was not available. For some of the road sections the road crash data was also available from Regional Offices using which an under-reporting factor was calculated. The operating speed (85th percentile speed) of vehicles were adopted based on data collected on Panipat-Chandigarh highway which has similar traffic operational characteristics.

The Star Ratings corresponding to speed limit of 80kmph show that over 60% of road length has 3-star or better safety ratings for vehicle occupant, 22% of road length for motorcyclist, just 1% for pedestrian and nil road length with 3-star or better for bicyclist.

The safety assessment was conducted by considering two different speed limits as mentioned below,

1. Posted speed limit as observed during the road surveys. In most of the road length the posted speed limit is 80kmph.
2. 100kmph as maximum speed limit for dual carriageway roads with 4-or more lanes specified in a recent notification issued by MoRT&H Dated 6th April 2018.

The chart given below compares Star Ratings for speed limit of 80kmph and 100kmph. Plots of vehicle occupant Star Ratings for the speed limit of 80kmph shows the road length with 3-star or better rating is nearly 60% whereas for the speed limit of 100kmph it is nearly 40%. This indicates increased risk of crash for road users at higher speed limit of 100kmph.



[4] http://tis.nhai.gov.in/

The Safer Roads Investment Plan (SRIP) gives a list of affordable and economically sound road safety treatments, specifically tailored to reduce risk on Delhi-Mumbai and Mumbai-Chennai sections of GQ. Each countermeasure proposed in the SRIP is supported by strong evidence that, if implemented, it will prevent deaths and serious injuries in a cost-effective way. Nevertheless, each countermeasure should be subject to additional prioritisation, concept planning and detailed design before implementation.

Three SRIP options were produced to prioritise countermeasure options for the two sections of GQ. Plan-1 was produced using a threshold BCR of 1 (that is, the economic benefit of each countermeasure must be greater than the cost), Plan-2 using a threshold BCR of 3, and Plan 3 using a threshold BCR of 5. Top-6 treatments of Plan-3 ranked as per the estimated reduction in deaths and severe injuries over 20-year analysis period are presented below.

Top-6 safety treatments recommended for Delhi-Mumbai and Mumbai-Chennai sections of GQ

Central median barrier

Length:	750.9km
Investment:	INR 194 crore
FSI Prevented:	20,200
BCR:	10

Shoulder rumble strips

Length:	4310km
Investment:	INR 67 crore
FSI Prevented:	16,500
BCR:	24

Intersection improvement

Length:	806 sites
Investment:	INR 154 crore
FSI Prevented:	14,100
BCR:	9

Roadside crash barriers

Length:	817.1km
Investment:	INR 212 crore
FSI Prevented:	13,800
BCR:	6

Duplication with median barrier

Length:	23.5km
Investment:	INR 46 crore
FSI Prevented:	10,400
BCR:	22

Improve Delineation

Length:	843.4 km
Investment:	INR 51 crore
FSI Prevented:	7,000
BCR:	13

Detailed list of safety treatments under SRIP suggests that significant safety improvements can be made to two sections of GQ through the implementation of several key route safety and mass action treatments. Top-6 such treatments are shown on the left. Details such as length or number of sites where the treatments are to be implemented, investment cost, how many deaths and serious injuries can be prevented in 20years and benefit-cost ratio are given for each treatment. More details are available https://vida.irap.org

An overview of three plans is provided in Table below. Note that the details shown in the table are a summary of the plans for Mumbai-Chennai section of GQ, details of all three plans are available in the detailed report and via the iRAP online software.

Table 3 Road Safety Investment Plan, Delhi-Mumbai and Mumbai – Chennai sections of GQ

	Plan-1 (BCR>1)	Plan-2 (BCR>3)	Plan-3 (BCR>5)
Present value of investment	₹ 4,215 crore	₹ 1,725 crore	₹ 968 crore
	$ 628 million	$ 257 million	$ 144 million
Deaths and serious injuries prevented	1,52,940	1,26,751	1,05,624
Present value of safety benefits	₹ 14,870 crore	₹ 12,324 crore	₹ 10,270 crore
	$ 2.2 billion	$ 1.8 billion	$ 1.5 billion
Cost per death and serious injury prevented	₹ 2,75,617	₹ 1,36,075	₹ 91,689
	$ 4,106	$ 2,027	$ 1,366
Benefit cost ratio (BCR)	4	7	11
Reduction in death and serious injuries	47%	39%	32%
Road length: 2760.3km; Assessment length: 5431.4km; and Analysis period: 20years			

Plan-1 outlines high value of road safety investments that is over INR 4,200 crore and promises 47% of reduction in number of deaths and severe injuries over 20years analysis period. The present value of benefits of saving lives and serious injuries would be over INR 14,000 crore with benefit-cost ratio of 4.

Plan-2 recommends medium value of road safety investment that is over INR 1,700 crore, that would prevent 39% of deaths and severe injuries in 20years with benefit to cost ratio of 7.

Plan-3 recommends low value of road safety investments that is over INR 900 crore, that would prevent 32% of deaths and severe injuries in 20years with benefit to cost ratio of 11.

Nevertheless, in interpreting the results of this safety assessment, it is important to recognise that iRAP is designed to provide a network-level assessment of risk and cost-effective countermeasures. As such, the safety improvement recommendations for Delhi-Mumbai and Mumbai-Chennai sections of GQ presented in this study should be considered just the first step in safe road infrastructure on the two corridors. For this reason, further local examination and preliminary scheme investigations should be carried out before implementation. For this purpose, World Bank and iRAP seek to conduct workshops and meetings with NHAI's field offices to disseminate the findings and help select feasible safety treatments from the investment plan presented above.