East African Community Secretariat

THE EAST AFRICAN TRADE AND TRANSPORT FACILITATION PROJECT

EAST AFRICAN TRANSPORT STRATEGY AND REGIONAL ROAD SECTOR DEVELOPMENT PROGRAM

FINAL REPORT

PART III: ROADS DEVELOPMENT PROGRAM

MARCH 2011

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STRUCTURE OF DOCUMENT

This report is made up of four parts:

- ***Part I*** provides the general background to the study. It reports on the analyses that are common to and form the foundation of the Transport Strategy and Roads Development Program, including the regional corridors, the economy and demography of the region, transport demand and transport modelling, and the principles for project identification and prioritisation.
- ***Part II*** is the Transport Strategy. It covers the policy/institutional arrangements in the transport sector in the EAC and its member countries. It then provides an overview of regional issues and identifies regional interventions in each of the transport modes, i.e. roads, rail, ports, pipelines, airports and border posts. It concludes by presenting the prioritised interventions together with an implementation approach.
- ***Part III*** (this document) is the Roads Development Program. It covers the regional roads network, and analyses roads needs from capacity and condition perspectives. It also develops some cross-cutting themes (regional roads classification system, regional roads management system and regional overload control). Regional roads projects are identified and described.
- ***Part IV*** is the list of transport projects, together with short profiles for the priority projects.

Parts II and III are drafted so that they can be read stand-alone, i.e. in isolation of the other three parts.

The report as a whole is summarised in a ***Summary Strategy*** which equally can be read stand-alone.

TERMS & ABBREVIATIONS

AADT	Annual average daily traffic
ACC	Area Control Centre
ADT	Average daily traffic
AfDB	African Development Bank
AICD	Africa Infrastructure Country Diagnostic
ANS	Air Navigation Service
bcf	Billion cubic feet
BOF	Berth Occupancy Factor
bpd	Barrels per day
CASSOA	Civil Aviation Safety
CCTFA	Central Corridor Transit Transport Facilitation Agency
CNS/ATM	Communication, Navigation and Surveillance in Air Traffic Management
COMESA	Common Market for Eastern and Southern Africa
DFI	Development Finance Institution
DRC	Democratic Republic of Congo
EAC	East African Community
EACDF	EAC Development Fund
ESA	Eastern and Southern Africa region (COMESA, EAC, IGAD and IOC)
FEU	Forty Foot Equivalent Unit
FIR	Flight Information Region
FONA	First order network assessment
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GIS	Geographic Information System
ha	Hectare
HCM	Highway Capacity Manual
HDM-4	Highway Design and Maintenance Model 4
IGAD	Inter-Governmental Authority for Development
IOC	Indian Ocean Community
IPPF	Infrastructure Project Preparation Facility
IRI	Roughness indicator and ride quality
JCA	Joint Competition Authority
JTC	Joint Technical Committee (on road transport)
KeNHA	Kenya National Highways Authority
KeRRA	Kenya Rural Roads Authority
km	kilometre
KOJ	Kurasini Oil Jetty
KOT	Kipevu Oil Terminal
KPC	Kenya Pipeline Company
KPC	Kenya Pipeline Company
kph	Kilometre per hour
KPRL	Kenya Petroleum Refineries Ltd
KRB	Kenya Roads Board

KRC	Kenya Railway Corporation
KURA	Kenya Urban Roads Authority
KWS	Kenya Wildlife Service
LOS	Level of Service
m	Metre
MCA	Multi-Criteria Analysis
Mlb	Million pounds
MOU	Memorandum of Understanding
Mt	Million Tonnes
Mtpa	Million Tonnes per annum
NCTTCA	Northern Corridor Transit Transport Coordination Authority
NG	Narrow Gauge
OD	Origin-Destination
OLC	Overload Control
OSBP	One Stop Border Post
pa	Per annum
pax km	Passenger kilometres
pax/ann.	Passengers per annum
PFF	Programme Finance Facility
PFI	Private Finance Initiative
PHF	Peak hour factor
PICU	Project Implementation and Coordination Unit
PIDG	Private Infrastructure Development Group
PMMR	Performance-based Maintenance and Management of Roads
PPIAF	Public-Private Infrastructure Advisory Facility
PPP	Public-Private Partnership
PSP	Private Sector Participation
REC	Regional Economic Community
RVR	Rift Valley Railways
SADC	Southern African Development Community
SBM	Single Buoy Mooring System
SG	Standard Gauge
SGr	Specific Gravity
SPM	Single Point Mooring
SPR	Special Purpose Roads
t	Tonnes
TAZAMA	Tanzania Zambia Mafuta Pipeline company
TAZARA	Tanzania Zambia Railway Authority
TEU	Twenty Foot Equivalent Unit
TICT	Tanzania International Container Terminal
TICTS	Tanzania International Container Terminal Services
TIPER	Tanzanian and Italian Petroleum Refining Company Ltd
TOR	Terms of Reference
tpa	Tonnes per annum
TPA	Tanzania Ports Authority

TRL	Tanzania Railways Limited
TTF	Tripartite Task Force
UACC	Upper Area Control Centre
UFIR	Upper Flight Information Region
UNCTAD	United Nations Conference on Trade and Development
URC	Uganda Railway Corporation
USD	United States Dollar
V/C	Volume over capacity ratio
VCI	Visual condition index
VFM	Value for Money
WEF	World Economic Forum
WP	Working Paper

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1. OBJECTIVES AND STRUCTURE

1.1 Terms of Reference

The objective of the **East African Community (EAC) Transport Strategy and Road Sector Development Program** is to identify regional strategic priorities and resources for transport sector development and operational needs for the medium term in line with EAC development goals.

There are two main work streams and deliverables:

- The ***EAC Transport Strategy*** covers an analytical review of the transport status in the region, the preparation of a regional transport model, and recommendations on the implementation of the Strategy, including institutional, financing and private sector participation arrangements
- The ***EAC Road Sector Development Program*** comprises a road characteristic survey, and assessment of road capacity and road condition, and the identification of priority roads projects and funding requirements.

1.2 Context of Road Development Program and Transport Strategy

This report addresses the second deliverable (**Road Sector Development Program**). It is the third part of a four-part final report:

- **Part I: Study Context and Framework**
- **Part II: Regional Transport Strategy**
- **Part III: Roads Sector Development Program**
- **Part IV: List of transport projects and profiles**.

The Strategy covers the transport modes of rail, ports, pipelines, airports and border posts – as well as roads. However, the Terms of Reference (TOR) requires a more in-depth analysis for roads and therefore a specific deliverable for this mode is presented.

1.3 Interrelationship between Road Capacity Assessment, Road Condition Assessment, and the Strategic Transport Model

The EAC Transport Strategy and Road Sector Development program was underpinned by the analysis undertaken using three distinct but interrelated models, namely:

- First Order Network Assessment (FONA) capacity assessment model
- Highway Design and Maintenance model – module 4 (HDM-4) road condition assessment model
- VISUM Strategic Transport Demand Model.

During the execution of the project it was critical that the interface between these models was facilitated through the transfer of data, analysis results and other outputs from one model to the next.

Figure 1-1 below demonstrates the relationship between the abovementioned models, whereas Table 1-1 indicates the interface levels between the models.

The models were structured in such a way in order to transfer data and model outputs seamlessly from one model to the next (refer to Figure 1-1 for a visual representation of this relationship between the models allowing for seamless transfers of data).

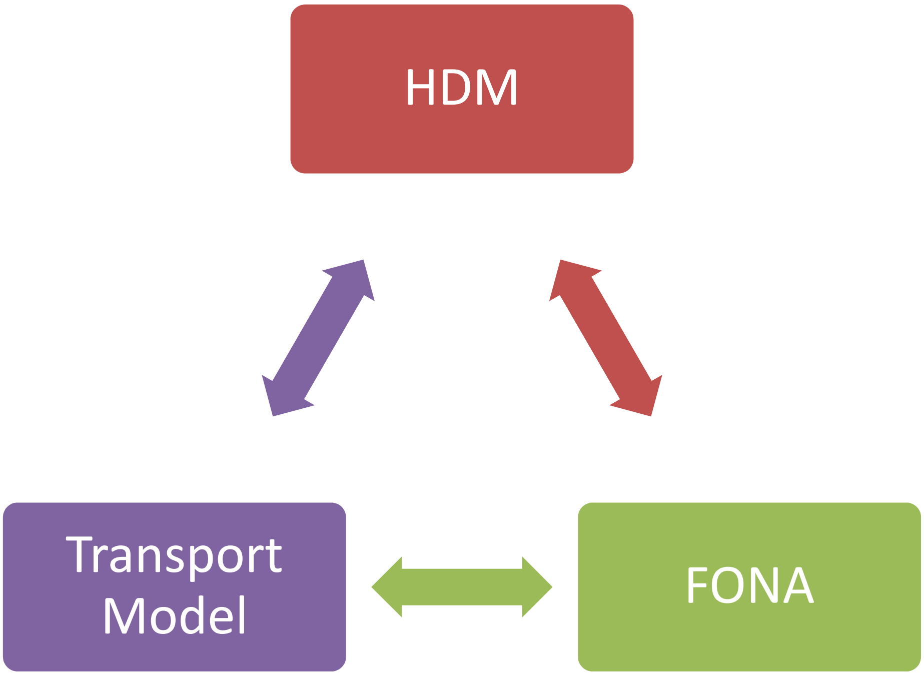


Figure 1-1: Relationship between the HDM Model; FONA and the Transport Model

Table 1-1: Interface of Roads Capacity Assessment (FONA) and Transport Model

Comparator	FONA	Transport Model (VISUM)	HDM-4
Focus	Roads Operational Capacity	All Modes (roads, rail, air, pipeline, etc.) Strategic	Roads Condition
Data Input	Network geometry Traffic volumes (30th highest hour – adopted from ADT) Network constraints	Land Use, Socio-economic Data Network geometry and constraints	Visual condition surveys IRI and video surveys
Output	LOS (two-lane facilities) in terms of percentage time-spent-following, LOS (two-lane facilities) in terms of average travel speed, LOS (multi-lane facilities) in terms of average passenger-car speed LOS (multi-lane facilities) in terms of traffic density	Traffic Volumes Desire Lines Volume-Capacity Ratios	Visual Condition Index (VCI)
Growth	Compound (static value)	Mode zone specific – linked to land use / socio-economic (dynamic)	Compound (static value)
Network	Existing links (paved links only)	Existing and new links	Existing links (paved and unpaved)
Assignment of Traffic	No traffic assignment (only volumes assessed)	Dynamic traffic assignment	No traffic assignment (only volumes assessed)

Source: Africon, 2010

The data set was hosted in a GIS platform where all the model parameters and the road geometry parameters could be linked to the physical location of the road segment. Other information pertaining to the corridor names, and model link preference numbers were also hosted in this file, therefore allowing standardisation, interrelationship and interface of data between the three model platforms (ie. FONA, HDM-4, VISUM).

1.4 Report Structure

Part III is structured as follows:

- Chapter 2: The EAC roads network is described, including the regional corridors as well as corridor feeder roads feeding into regional corridors. A proposal is made on introducing a common roads classification system for regional roads
- Chapter 3: The underlying approach to analysing the roads network is presented, covering the trade-offs between roads capacity, condition and traffic
- Chapter 4: The traffic data applied in the analysis was obtained from the respective partner states and amplified by traffic counts and origin-destination surveys carried out by the study team
- Chapter 5: The analysis of road capacity is based on the First Order Network Assessment (FONA) model. The model identifies areas where additional lanes are required to address capacity constraints
- Chapter 6: Roads condition is assessed based on HDM-4. The analysis identifies areas where roads need to be paved or rehabilitated
- Chapter 7: Part of the explanation for roads condition is the prevalence of overloading in the region. This topic is reviewed and a proposal made on a regional overload control (OLC) approach
- Chapter 8: One of the salient themes in the roads analysis is the availability of standardised roads data amongst the partner states. This limitation could be overcome by implementing a region-wide integrated roads management approach
- Chapter 9: A comparison is made between the performances of the main EAC corridors with two corridors in South Africa. The purpose is to show in practice how the aspects considered in the roads analysis impact on overall road performance.

2. ROAD NETWORKS

2.1 EAC Roads Network

The definitive purpose of a road network is to support and sustain social and economic development. The EAC Roads Sector Development Program has identified road network corridors that play an important role within the EAC as a whole and forms the foundation to support and sustain social and economic development within the EAC and all its Member States.

The EAC Road network corridors are summarised below followed by a detailed description table (refer to Table 2-1):

- Mtwara Corridor
- Dar es Salaam (TAZARA) Corridor
- Coastal Corridor
- Central Corridor
- Sumbawanga Corridor
- Gulu Corridor
- Sirari Corridor
- Northern Corridor
- Namanga Corridor
- Arusha Corridor
- Gulu Corridor

Apart from the main corridors themselves, the roads analysis also covers the so-called corridor feeders. These are roads that are not part of the corridor *per se*, but that link into the corridor and feed traffic onto and from the corridor. The EAC Road network corridor feeders are summarised below followed by a detailed description table (refer to Table 2-2 below):

- Taveta/Voi Northern Corridor feeder
- Kitui Northern Corridor feeder
- Narok Northern Corridor feeder
- Kisumu/Bugiri Northern Corridor feeder
- Masindi Northern Corridor feeder
- Hoima Northern Corridor feeder
- Fort Portal Northern Corridor feeder
- Kabatoro Northern Corridor feeder
- Tukuyu Dar es Salaam (TAZARA) Corridor feeder
- Garissa Namanga Corridor feeder
- Singida/Babati Namanga Corridor feeder
- Moroto Gulu Corridor feeder.

Table 2-1: EAC Road Corridors

EAC Road Corridor Name	EAC Road Corridor Description	EAC Road Corridor Length (rounded)
Northern Corridor	Mombasa-Voi-Eldoret-Bugiri-Kampala-Masaka-Kigali-Kibuye-Kayanza-Bujumbura	1 900km
Central Corridor	Dar es Salaam-Morogoro-Dodoma-Singida-Nzega-Nyakanazi-Kigali-Gisenyi	3 100km
Dar es Salaam (TAZARA) Corridor	Morogoro-Iringa-Mbeya-Tunduma	1 100km

EAC Road Corridor Name	EAC Road Corridor Description	EAC Road Corridor Length (rounded)
Namanga Corridor	Iringa-Dodoma-Kalema-Arusha-Nairobi-Thika-Murang'a-Embu-Nyeri-Nanyuki-Isiolo-Marsabit-Moyale	1 800km
Sumbawanga Corridor	Tunduma-Sumbawanga-Kasulu-Makamba-Nyanza Lac-Rumonge-Bujumbura	1 300km
Sirari Corridor	Lokichokio-Lodwar-Kitale-Bungoma-Kisumu-Kisii-Mwanza-Biharamulo	1 500km
Coastal Corridor	Mingoyo-Dar es Salaam; Chalinze-Vanga-Mombasa-Malindi-Lamu	1 500km
Mtwara Corridor	Mtwara-Mingoyo-Masasi-Tunduru-Songea-Mbamba Bay	800km
Arusha Corridor	Arusha-Moshi-Himo-Lushoto-A1	500km
Gulu Corridor	Nimule-Bibia-Gulu-Lira-Soroti-Mbale-Tororo	600km
Total EAC Road Corridor Network Length		**14 100km**

Source: Africon, 2010

Note: All lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

From Table 2-1 above the following conclusions can be drawn:

- There are ten (10) Road Corridors that have been identified by the EAC, spanning approximately 14 100km in total
- The Central Corridor is notably the longest of the identified EAC Corridors, spanning approximately 3 100km in length
- The Arusha Corridor is notably the shortest of the identified EAC Corridors, spanning approximately 500km in length.

Table 2-2 below summarises the EAC Road Corridor feeders that feed into and out of the identified EAC Road Network Corridors.

Table 2-2: EAC Road Corridor Feeders

EAC Road Corridor Feeder Name	EAC Road Corridor Feeder Description	Length (rounded)
Taveta/Voi Northern Corridor Feeder	Voi-Taveta-Himo	150km
Kitui Northern Corridor Feeder	Kitui Road Northern Corridor Intersection to Garissa Road via Kitui	200km
Narok Northern Corridor Feeder	Ewaso-Ngorongoro-Bakitabu; Ngorongoro-Migori; Kericho; From Northern Corridor to Kisii via Narok Tukuyu Dar Es Salaam (Tazara) Corridor	900km
Kisumu/Bugiri Northern Corridor Feeder	Bugiri to Kisumu	150km

EAC Road Corridor Feeder Name	EAC Road Corridor Feeder Description	Length (rounded)
Masindi Northern Corridor Feeder	Kampala to Masindi	300km
Hoima Northern Corridor Feeder	Kampala to Hoima	200km
Fort Portal Northern Corridor Feeder	Kampala to Fort Portal	300km
Kabatoro Northern Corridor Feeder	Mbarara to Fort Portal via Kabatoro	250km
Tukuyu Dar es Salaam (TAZARA) Corridor Feeder	Mbeya to Takuyu	150km
Garissa Namanga Corridor Feeder	Thika to Somalia Border via Garissa	1 250km
Singida/Babati Namanga Corridor Feeder	Singida to Babati	200km
Moroto Gulu Corridor Feeder	Soroti to Moroto to Mbale	400km
Total EAC Road Corridor Feeder Network Length		**4 450km**

Source: Africon, 2010

Note: All lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

With regards to Table 2-2 above, the following conclusions can be drawn:

- There are twelve (12) corridor feeders included in the roads analysis, spanning approximately 4 450km in total
- The Garissa Namanga Corridor feeder is the longest of the identified EAC Corridor Feeders, spanning approximately 1 250km
- The Tukuyu Dar es Salaam (TAZARA) Corridor feeder is notably the shortest of the identified EAC corridor feeders, spanning approximately 150km.

The following Map 2-1 spatially depicts the EAC road corridors and corridor feeders.

Table 2-3 and Table 2-4 below summarise key characteristics of the EAC road corridors and corridor feeder network in terms of the following:

- Volume (30^{th} highest hourly traffic volume)
- Base Free Flow Speed
- Estimated Road Reserve
- Classification in terms of Urban and Rural
- Surface Type (Paved or Unpaved)
- Number of accesses.

Map 2-1: EAC Road Corridors and Road Corridor Feeders

Table 2-3: EAC Road Network Key Characteristics Summary per Road Length (km) – Current 2010[

Corridor / Corridor Feeder Name	Length (km)	%	30th Highest Hourly Traffic Volume per Travel Direction										Base Free Flow Speed			Road Reserve		Classification		Surface Type		Number of Accesses				
			0-50	51-100	101-200	201-300	301-400	401-500	501-50	751-1000	1001-1500	1501-2000	70 km/h	80 km/h	90 km/h	10.6m	17.6m	Rural	Urban	Paved	Un-paved	0	1	2	3	>=4
Arusha Corridor	500	2%	29	255	4	63	35	0	18	4	9	0	0	41	377	418	0	418	0	389	29	275	6	97	0	40
Central Corridor	3100	17%	2412	396	0	159	0	83	24	9	10	5	152	1419	1529	3026	73	2974	125	2651	448	2382	428	164	86	40
Coastal Corridor	1500	8%	612	535	98	69	7	9	46	12	16	5	0	520	890	1377	34	1227	184	1256	154	1150	172	26	13	49
Fort Portal Northern Corridor Feeder	300	2%	65	150	67	2	0	0	0	0	0	0	0	284	1	283	1	284	0	284	0	267	17	0	0	0
Garissa Namanga Corridor Feeder	1300	7%	954	49	207	0	0	0	36	0	0	0	266	494	486	1246	0	1239	7	1053	194	1210	0	36	0	0
Gulu Corridor	600	3%	344	128	29	7	0	0	0	0	0	0	24	15	471	508	2	441	69	402	107	493	17	0	0	0
Hoima Northern Corridor Feeder	200	1%	43	126	22	0	7	0	0	0	0	0	88	108	2	198	0	192	7	198	0	198	0	0	0	0
Kabatoro Northern Corridor Feeder	300	1%	36	161	0	1	18	8	0	5	0	0	63	106	60	229	0	224	5	228	1	229	0	0	0	0
Kisumu/Bugiri Northern Corridor Feeder	200	1%	16	101	24	0	0	0	0	0	0	0	53	72	16	142	0	142	0	141	0	142	0	0	0	0
Kitui Northern Corridor Feeder	200	1%	185	9	0	0	0	0	0	0	0	0	0	194	0	194	0	185	9	34	160	194	0	0	0	0
Masindi Northern Corridor Feeder	300	2%	6	144	99	10	0	11	0	0	0	0	24	20	226	270	0	260	11	270	0	270	0	0	0	0
Moroto Gulu Corridor Feeder	400	2%	375	19	0	0	0	0	0	0	0	0	31	48	315	394	0	386	8	40	354	394	0	0	0	0
Mtwara Corridor	800	4%	738	0	0	0	0	0	0	0	0	0	45	331	362	738	0	691	46	207	531	682	38	0	0	18
Namanga Corridor	1800	10%	1094	242	159	25	14	0	96	26	43	40	84	1280	374	1592	146	1521	217	826	912	1453	105	86	44	51
Narok Northern Corridor Feeder	900	5%	559	0	319	0	0	0	0	0	0	0	183	695	0	879	0	841	38	366	513	879	0	0	0	0
Northern Corridor	1900	11%	54	105	783	466	326	37	51	70	5	0	851	889	157	1737	160	1569	329	1895	2	1633	120	88	56	0
Sirari Corridor	1500	8%	970	136	281	21	1	11	0	0	0	0	842	361	216	1418	1	1389	30	1203	216	1368	28	23	0	0
Singida/Babati Namanga Corridor Feeder	200	1%	155	0	0	0	0	0	0	0	0	0	0	45	111	155	0	152	4	15	140	140	15	0	0	0
Sumbawanga Corridor	1300	7%	1215	0	0	0	0	0	5	0	0	0	22	296	902	1220	0	1159	61	311	909	1207	7	0	0	7
Taveta/Voi Northern Corridor Feeder	200	1%	122	2	4	0	0	0	0	0	0	0	0	129	0	129	0	125	4	39	90	129	0	0	0	0
Dar es Salaam (TAZARA) Corridor	1100	6%	148	674	35	176	14	7	0	9	10	5	0	214	866	1074	5	1047	32	1015	64	609	168	147	19	137
Tukuyu Dar es Salaam (TAZARA) Corridor Feeder	200	1%	71	30	22	0	0	0	0	0	0	0	0	98	25	123	0	117	6	59	64	100	9	0	0	14
TOTAL	**17800**	**100%**	**10206**	**3263**	**2156**	**999**	**422**	**167**	**277**	**135**	**93**	**56**	**2731**	**7657**	**7385**	**17351**	**422**	**16583**	**1189**	**12883**	**4890**	**15404**	**1130**	**667**	**218**	**355**

Source: Africon, 2010

Table 2-4: EAC Road Network Key Characteristics Summary Percentages – Current (2010)

Corridor / Corridor Feeder Name	Length (km)	%	30th Highest Hourly Traffic Volume per Travel Direction										Base Free Flow Speed			Road Reserve.		Classification		Surface Type		Number of Accesses				
			0-50	51-100	101-200	201-300	301-400	401-500	501-750	751-1000	1001-1500	1501-2000	70 km/h	80 km/h	90 km/h	10.6m	17.6m	Rural	Urban	Paved	Un-paved	0	1	2	3	>=4
Arusha Corridor	500	2%	7%	61%	1%	15%	9%	0%	4%	1%	2%	0%	0%	10%	90%	100%	0%	100%	0%	93%	7%	66%	1%	23%	0%	10%
Central Corridor	3100	17%	78%	13%	0%	5%	0%	3%	1%	0%	0%	0%	5%	46%	49%	98%	2%	96%	4%	86%	14%	77%	14%	5%	3%	1%
Coastal Corridor	1500	8%	43%	38%	7%	5%	1%	1%	3%	1%	1%	0%	0%	37%	63%	98%	2%	87%	13%	89%	11%	82%	12%	2%	1%	3%
Fort Portal Northern Corridor Feeder	300	2%	23%	53%	24%	1%	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%	0%	100%	0%	100%	0%	94%	6%	0%	0%	0%
Garissa Namanga Corridor Feeder	1300	7%	77%	4%	17%	0%	0%	0%	3%	0%	0%	0%	21%	40%	39%	100%	0%	99%	1%	84%	16%	97%	0%	3%	0%	0%
Gulu Corridor	600	3%	68%	25%	6%	1%	0%	0%	0%	0%	0%	0%	5%	3%	92%	100%	0%	87%	13%	79%	21%	97%	3%	0%	0%	0%
Hoima Northern Corridor Feeder	200	1%	22%	64%	11%	0%	3%	0%	0%	0%	0%	0%	45%	55%	1%	100%	0%	97%	3%	100%	0%	100%	0%	0%	0%	0%
Kabatoro Northern Corridor Feeder	300	1%	16%	70%	0%	0%	8%	4%	0%	2%	0%	0%	27%	46%	26%	100%	0%	98%	2%	99%	1%	100%	0%	0%	0%	0%
Kisumu/Bugiri Northern Corridor Feeder	200	1%	12%	72%	17%	0%	0%	0%	0%	0%	0%	0%	38%	51%	11%	100%	0%	100%	0%	100%	0%	100%	0%	0%	0%	0%
Kitui Northern Corridor Feeder	200	1%	96%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%	0%	95%	5%	17%	83%	100%	0%	0%	0%	0%
Masindi Northern Corridor Feeder	300	2%	2%	53%	37%	4%	0%	4%	0%	0%	0%	0%	9%	8%	84%	100%	0%	96%	4%	100%	0%	100%	0%	0%	0%	0%
Moroto Gulu Corridor Feeder	400	2%	95%	5%	0%	0%	0%	0%	0%	0%	0%	0%	8%	12%	80%	100%	0%	98%	2%	10%	90%	100%	0%	0%	0%	0%
Mtwara Corridor	800	4%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	45%	49%	100%	0%	94%	6%	28%	72%	92%	5%	0%	0%	2%
Namanga Corridor	1800	10%	63%	14%	9%	2%	1%	0%	6%	2%	3%	2%	5%	74%	22%	92%	8%	88%	12%	48%	52%	84%	6%	5%	3%	3%
Narok Northern Corridor Feeder	900	5%	64%	0%	36%	0%	0%	0%	0%	0%	0%	0%	21%	79%	0%	100%	0%	96%	4%	42%	58%	100%	0%	0%	0%	0%
Northern Corridor	1900	11%	3%	6%	41%	25%	17%	2%	3%	4%	0%	0%	45%	47%	8%	92%	9%	83%	17%	100%	0%	86%	6%	5%	3%	0%
Sirari Corridor	1500	8%	68%	10%	20%	1%	0%	1%	0%	0%	0%	0%	59%	25%	15%	100%	0%	98%	2%	85%	15%	96%	2%	2%	0%	0%
Singida/Babati Namanga Corridor Feeder	200	1%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	29%	71%	100%	0%	98%	2%	10%	90%	90%	10%	0%	0%	0%
Sumbawanga Corridor	1300	7%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	24%	74%	100%	0%	95%	5%	26%	74%	99%	1%	0%	0%	1%
Taveta/Voi Northern Corridor Feeder	200	1%	95%	2%	3%	0%	0%	0%	0%	0%	0%	0%	0%	100%	0%	100%	0%	97%	3%	30%	70%	100%	0%	0%	0%	0%
Dar es Salaam (TAZARA) Corridor	1100	6%	14%	63%	3%	16%	1%	1%	0%	1%	1%	1%	0%	20%	80%	100%	1%	97%	3%	94%	6%	56%	16%	14%	2%	13%
Tukuyu Dar es Salaam (TAZARA) Corridor Feeder	200	1%	57%	24%	18%	0%	0%	0%	0%	0%	0%	0%	0%	80%	20%	100%	0%	95%	5%	48%	52%	81%	7%	0%	0%	12%
TOTAL	**17800**	**100%**	**57%**	**18%**	**12%**	**6%**	**2%**	**1%**	**2%**	**1%**	**1%**	**0%**	**15%**	**43%**	**42%**	**98%**	**2%**	**93%**	**7%**	**72%**	**28%**	**87%**	**6%**	**4%**	**1%**	**2%**

Source: Africon, 2010

2.2 EAC Road Classification Systems

2.2.1 Introduction

The definitive purpose of a road network is to support and sustain social and economic development. In order to achieve such a goal, roads must be classified and managed in a sustainable way to optimise safety, reduce congestion and maximise road efficiency by way of standardising road classification and road design.

As a result of differences in legal and historical backgrounds and administrative requirements, there are variations between the road classification systems currently in place in the Member States of the EAC. However in spite of these differences, the current road classifications that are in place within the EAC Member States and which focus on high mobility (Class 1 – 3) are similar in terms of their function (refer to Table 2-5 below).

High-mobility roads are vehicle-priority roads or routes that have higher operating speeds as well as design speeds, where vehicular movement is dominant and access and pedestrian crossings are limited to areas that are defined and clearly distinguished at widely-spaced intervals. An access street, on the other hand, serves a local purpose and caters for the full range of human activity and functions predominantly in providing access for both vehicles and pedestrians from the street to adjacent land. Figure 2-1 demonstrates graphically the mobility and access functionality of roads and is based on current international best practice. The highlighted area (in red) demonstrates the road classification on which this Regional Road Sector Development Program investigation is focused.

The Roads Sector Development Program, when considering road classification, focuses on roads that play an important role within the EAC as a whole. Therefore, this section investigates current road classification systems within the Member States of the EAC, international best practice, and introducing a formal EAC regional road classification approach. The underlying motivation is that if some roads are of regional importance, they should be recognised as such, and be constructed, maintained and operated at a region-wide standard.

The following sections of the report provide information on the current road classification system of each of the Member States with a focus on the high-mobility roads and routes that are considered to be of EAC importance (i.e. roads that play an important role within the EAC as a whole in terms of improving, sustaining, and supporting social and economic development).

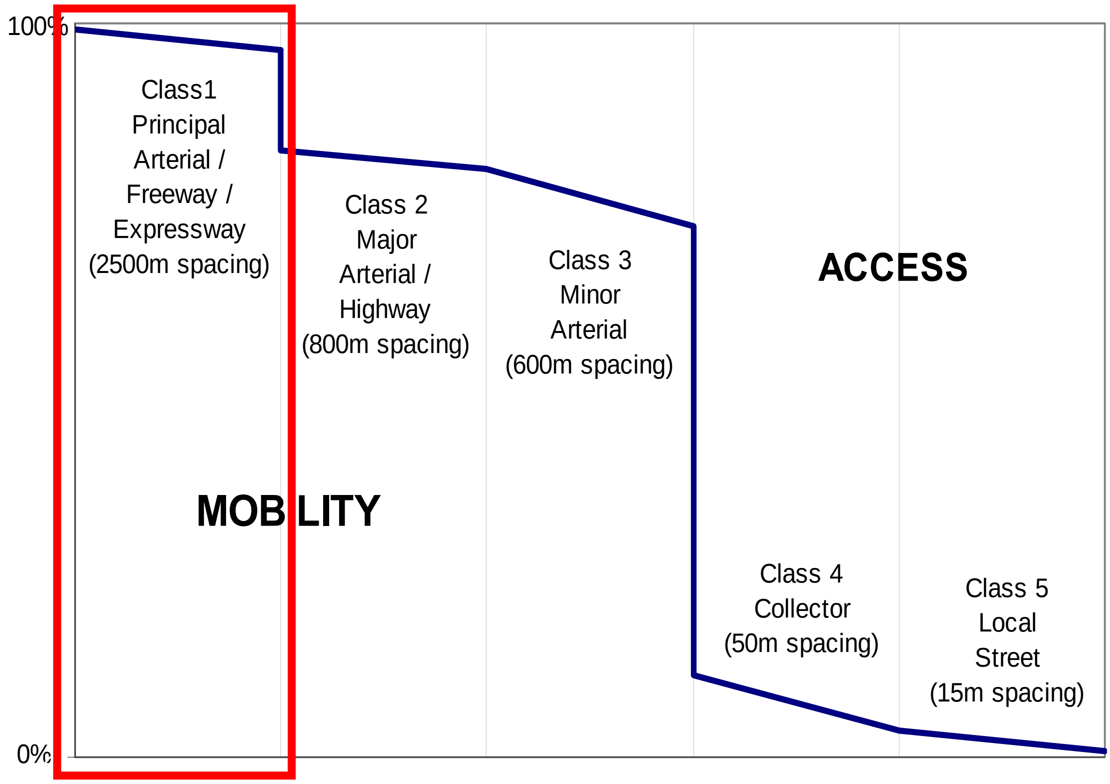


Figure 2-1: Functional Classification of Mobility Roads and Access Roads

Table 2-5: Summary of EAC Member States' Road Classification

Function Definition	Classification	EAC Member States				
		Burundi	**Kenya**	**Rwanda**	**Tanzania**	**Uganda**
Mobility (Arterial) Movement/mobility is dominant, through traffic is dominant, the majority of traffic does not originate or terminate in the immediate vicinity, the function of the road is to carry high volumes of traffic between urban districts.	**1**	Class RN- National Roads	Class A- International Trunk Roads	Class RN- Route National (Bitumen surfacing)	Trunk Roads (Paved & Unpaved)	National (Trunk) Roads
	2	Class RP- Provincial Roads	Class B- National Trunk roads	Class RN- Route National (Gravel surfaces)	Regional Roads (Paved & Unpaved)	District (Feeder) Roads
	3	Class RC- Communal Roads	Class C- Primary roads	Class RD- Route District (Gravel)	District Roads (Gravel)	Urban Roads (Tarmac and Gravel)

Notes: An EAC-specific corridor road classification should be focussed on Class 1 roads as demonstrated above as these have the highest function. The identified EAC road corridor classification should therefore have the highest mobility road classification as this would support its intended function.

Sources: Logistics Capacity Assessment Reports of EAC Member States

Kenya National Highways Authority (KeNHA)

Tanzania National Roads Agency (TANROADS)

2.2.2 Burundi: Current Road Classification

According to the Logistics Capacity Assessment of Burundi (2008), it has over 11 000 km of roads divided into two categories, namely:

- **Classified Network**. This is under the responsibility of the Ministry of Public Works and Equipment and managed by Office des Routes (OdR)
- **Unclassified Network.** The 'unclassified' network is managed by local governments and councils, and distributed following geographical boundaries. This category includes urban roads that fall in the capital city of Bujumbura.

Table 2-6: Burundi Road Classification (high mobility functional classification only) and Description

Road Classification	Road Description
National Road (RN)	Road with international links to Bujumbura and the major towns. (Bitumen surfacing and gravel)

Source: Logistics Capacity Assessment – Burundi, 2008

2.2.3 Kenya: Current Road Classification

There are approximately 161 000km of public roads in the country of which approximately 62 000km is classified while approximately 99 000km is unclassified (although a road classification study has been completed and awaiting approval from the Kenya Ministry of Roads). The Government intends to undertake a complete road inventory and condition survey of these roads starting in 2011.

Currently, as stipulated in the Kenya Roads Act 2007, the management of the road sub-sector in Kenya is as follows:

- The Ministry of Roads is in charge of policy and strategy relating to the provision of roads, including regulatory areas such as technical standards (including axle load control). The Ministry approves development budgets of the implementing agencies
- The Kenya Roads Board (KRB) funds maintenance of all roads including approval of Roads Maintenance Levy Fund (RMLF) funded maintenance work programmes, and carrying out of technical and financial audits of the works. KRB is under Ministry of Roads and report to the Minister responsible for Roads
- The Roads Department provides technical and support services to the roads authorities
- The Kenya National Highways Authority (KeNHA) manages and maintains all road works on Class A, B, C roads. In addition to the implementation of works, KeNHA advises the Ministry of Roads on technical issues such as standards, axle load, research and development
- Kenya Rural Roads Authority (KeRRA) is responsible for all rural and small town roads, Class D and below including special purpose roads and unclassified roads (currently under County Councils and town councils), also responsible for Forest Department Roads and County Council Game Reserve Roads

- Kenya Urban Roads Authority (KURA) is responsible for all road works on urban roads in Cities and Municipalities. It should be noted that Local Authorities still are major stakeholders in prioritising road works that are implemented by KURA
- The Kenya Wildlife Service (KWS) is responsible for roads in National Parks and National Reserves as well as access roads allocated to it by the Ministry of Roads. KWS, just like the three roads authorities, report to the Ministry of Roads on road development projects while Kenya Roads Board approves its maintenance works.

With the promulgation of a new constitution in Kenya in 2010, the above structure of road management in Kenya will soon change. As stipulated in the fourth schedule on the distribution of functions between the national government and the county governments, the national government will be responsible for the construction and operation of national trunk roads (Classes A, B, C) and setting of standards for the construction and maintenance of other roads by counties. County governments will be responsible for county roads (Classes D, E, SPR and unclassified) and public road transport. Table 2-7 below provides a summary of Kenya Road Class Definitions.

Table 2-7: Kenya Road Classification Definitions

Road Class	Definition
International Trunk Roads (Class A)	Roads that link centres of international importance and crossing international boundaries or terminating at international ports
National Trunk Roads (Class B)	Roads linking nationally important centres
Primary roads(Class C)	Roads linking provincially important centres to each other or two higher class roads
Secondary roads(Class D)	Roads linking locally important centres to each other, to more important centres or to higher class roads
Minor roads (Class E)	Roads providing connections to minor centres
Special Purpose Roads(SPR)	Are identified by the service they provide e.g. agriculture and tourist access roads: Class F: Forest roads Class G: Roads serving Government institutions Class K: Roads accessing coffee (Kahawa) growing areas Class L: Roads accessing settlement scheme areas Class P: National park roads Class R: Roads accessing rural areas Class S: Roads accessing sugar growing areas Class T: Roads accessing tea growing areas Class U: Unclassified rural roads including mining roads etc Class W: Roads accessing wheat growing areas.
Unclassified Roads (U)	Roads serving communities, their farms and the villages and link to classified or SPR

Source: Road Inventory and Condition Unit, MOR 2009

2.2.4 Rwanda: Current Road Classification

Rwanda's Road Network is at present classified into National or District and by surfacing (bitumen or gravel).

Table 2-8: Rwanda Current Road Classification (high mobility classification only) and Description

Classification	Road Description
Class – **RN**	**Route National (Bitumen)** – There is 13 routes under this classification; they have bitumen surfacing and are international links with Kigali and the major towns within Rwanda.
Class – **RN**	**Route National (Gravel)** – There is 30 routes under this classification; they have gravel surfaces and are international links with Kigali and the major towns.

Source: Logistics Capacity Assessment – Rwanda, 2007

The size of Rwanda's Road Network is estimated at 14 000 km comprising some 5 000km classified roads and about 9 000km of unclassified roads (including urban roads and streets).

2.2.5 Tanzania: Current Road Classification

There are presently five classification categories for roads in Tanzania, namely:

- **Trunk Roads** are the primary national and international through routes that link several regions and provide access to important border posts and ports
- **Regional Roads** are the secondary routes connecting district centres in a region or connecting another important centre to a trunk road
- **District Roads** are tertiary routes linking: district headquarters with ward centres; important centres within the district; important centres to a higher class road
- **Feeder Roads** are the village access roads linking important centres within a ward to the rest of the network
- **Urban Roads** comprise the roads within urban centres and consist of: Arterial Roads, Collector Roads, Local Collector Roads and Access Roads.

Trunk and regional roads are the responsibility of TANROADS, whilst the District, Urban and Feeder roads are the responsibility of the President's Office for Regional Administration and Local Government (PORALG).

2.2.6 Uganda: Current Road Classification

The national road system is functionally categorised so that each road is geometrically characterised to deliver the intended level of service. The design features that convey this include carriageway width, continuity of alignment, spacing of functions, frequency of access, standards of alignment and grade, traffic controls and road reserve widths. The national road system is divided into three main functional categories 'A', 'B' and 'C' as follows: -

- **A – Primary Roads**: main international routes and linkage between provincial capitals as well as urban centres
- **B – Secondary Roads**: connections between regional communities and the primary road network
- **C – Tertiary Roads**: collectors or local roads, which provide access to small communities and district administrative centres.

The national road system is divided into six road classes governed by the design speed, surface type and design traffic. The classes for the paved roads are I, II and III while those for unpaved roads are A, B and C. The factors that affect road capacity include design speed, road width, lateral clearance, grade, traffic composition, type of surface, peaking factors and level of service.

2.3 Road Classification – International Best Practice

This Section demonstrates road classification by various international transport authorities and highlights the different naming conventions that have similar functions in terms of road classification (refer to Table 2-9). Taken a step further, Table 2-10 includes current road classification naming conventions of the EAC Member States compared to international transport authorities in order to demonstrate different naming conventions that have similar functionality.

It is important to note that the focus of the Regional Roads Sector Development Program in terms of road classification is to identify and determine an EAC regional road classification that clearly identifies those roads of regional importance so that they can be provided, operated and maintained at appropriate standards.

Table 2-9: Road Classification by various Transport Authorities Worldwide

Country		South Africa			USA				International		
Function	Class.	RCAM 2010	RAM 2005	RISFSA 2006	AASHTO 1973, 2004, FHA 1989; both urban and rural	ITE 1988, NCHRP 1992	TRB 2003: Access Manual: State	TRB 2003: Access Manual: Local	Great Britain ordnance survey, DfT, HA	Australia	New Zealand
Mobility (arterial)	1	Principal arterial	Principal arterial	Primary distributor	Principal arterial system, interstate	Freeway, expressway	1 Interstate highways and other freeways	1 Freeway	Motorway, trunk roads	Freeway, M-route, state road, national highway	National road
	2	Major arterial	Major arterial	Regional distributor	Principal arterial system, other	Strategic arterial, principal arterial, primary arterial	2 Roadway of state-wide importance (strategic, principal arterials)	2 Major arterial	A-road, principal road	Major arterial, A-route, regional road	Primary (regional) arterial
	3	Minor arterial	Minor arterial / activity arterial - spine	District distributor	Minor arterial road / street system	Secondary arterial	3 Roadway of regional importance (other arterials)	3 Minor arterial	B-road	Minor arterial, B-route, district road, sub-arterial	Secondary (district) arterial
Access / Activity (street)	4	Collector (street) *(4a commercial, 4b residential)*	Activity street	District collector	Major collector road / street system, minor collector roads	collector	4 District roadway (collector)	4 Major collector, 5 Minor collector	C-road, minor roads	Collector, C-route	Collector road
	5	Local street *(5a commercial, 5b residential)*	Residential street	Access roads	local road / street system	local, cul-de-sac	5 Local	6 Local	Local street, alley, private road with or without public access	local, lane	Local road
	6	Walkway *(6a pedestrian priority, 6b pedestrian only)*	Non-motorised	Non-motorised access ways	Terminal and transfer facilities				pedestrianised street with restricted access		

Notes: AASHTO 1973 A policy on Design of Urban Highways and Arterial Streets 1973 (red book)

AASHTO 2004 A policy on Geometric Design of Highways and Streets 2004 (green book)

FHA 1989 Highway functional classification, US DOT, Federal Highway Administration, March 1989

GB, Aus, NZ Assessing the feasibility of a National Road Classification, Intergovernmental Committee on Surveying and Mapping, Australia Oct 2006

ITE 1988 Transportation and Land Development, ITE, Stover and Koepke, 1988

RAM 2005 National Guidelines for Road Access Management in South Africa, October 2005 draft

RCAM 2010 National Guidelines for Road Classification and Access Management in South Africa, 2010

RISFSA 2006 Road Infrastructure Strategic Framework for South Africa, October 2006 (earlier version 2002)

TRB 2003 Access Management Manual, Transportation Research Board of the National Academies, 2003

Source: RCAM 2010 National Guidelines for Road Classification and Access Management in South Africa, 2010

Table 2-10: Road Classification (High Mobility) of South Africa, Great Britain, Australia, New Zealand and the EAC Member States

Function Definition	Classification	South Africa	EAC Member States					International		
		RCAM 2010	Burundi	Kenya	Rwanda	Tanzania	Uganda	Great Britain	Australia	New Zealand
Mobility (Arterial) Movement/mobility is dominant, through traffic is dominant, the majority of traffic does not originate or terminate in the immediate vicinity, the function of the road is to carry high volumes of traffic between urban districts.	1	Principal Arterial	Class RN- National Roads	Class A- International Trunk roads	Class RN- Route National (Bitumen surfacing)	Trunk Roads (Paved & Unpaved)	National (Trunk) Roads	Motorway, trunk roads	Freeway, M-route, state road, national highway	National road
	2	Major Arterial	Class RP- Provincial Roads	Class B- National Trunk roads	Class RN- Route National (Gravel surfaces)	Regional Roads (Paved & Unpaved)	District (Feeder) Roads	A-road, principal road	Major arterial, A-route, regional road	Primary (regional) arterial
	3	Minor Arterial	Class RC- Communal Roads	Class C- Primary roads	Class RD- Route District (Gravel)	District Roads (Gravel)	Urban Roads (Tarmac and Gravel)	B-road	Minor arterial, B-route, district road, sub-arterial	Secondary (district) arterial

Sources: *RCAM,2010 ; Logistics Capacity Assessment Reports of EAC Member States and Roads Agencies of Member States*

Note: *Classification 1 is considered the basis from which an EAC Regional Corridor Classification should be based upon (refer dark blue highlighted area)*

2.3.1 Regional or Inter-State Road Network – International Best Practice

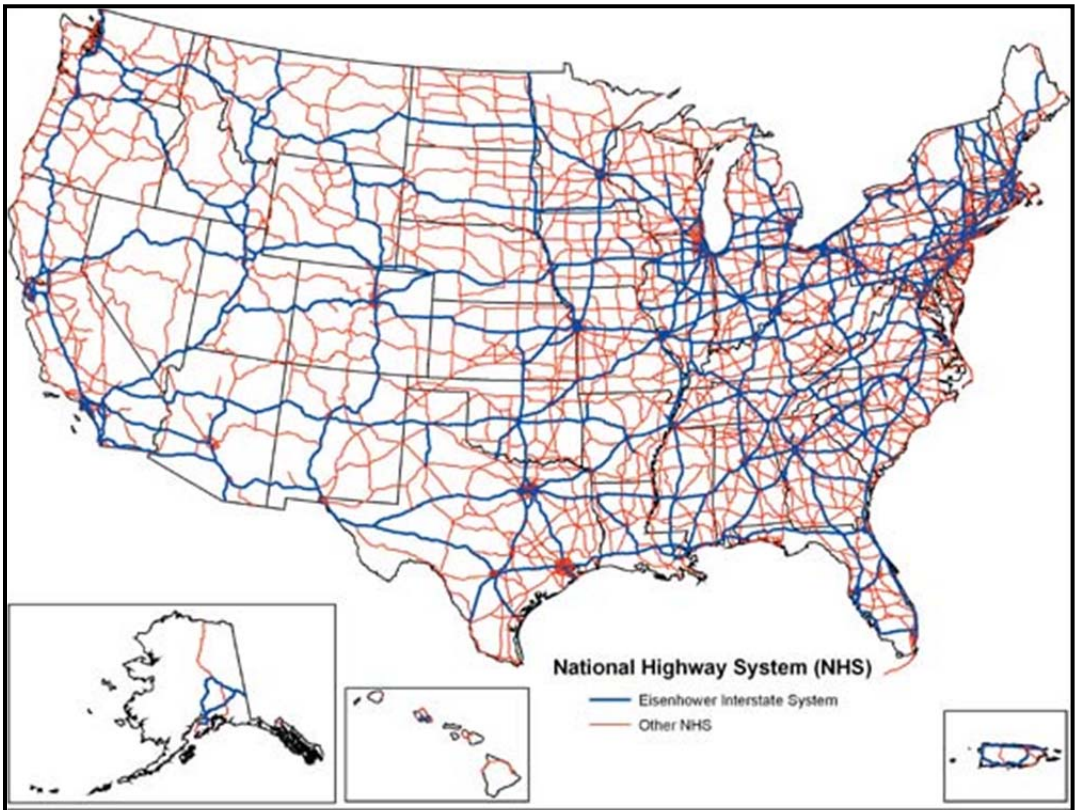
The following sections highlight international best practice examples in terms of providing a unified road network across country/state borders.

2.3.1.1 America

The National Highway System (NHS) of the United States comprises approximately 160 000 miles (256 000km) of roadway, including the Interstate Highway System and other roads, which are important to the nation's economy, defence and mobility (refer to Figure 2-2). The NHS was developed by the United States Department of Transportation in cooperation with the states, local officials, and metropolitan planning organisations. Its main purpose is to coordinate federal funding as most of the roads (including the Interstates) are maintained by the federal states.

Establishment of the NHS encourages states to focus on a limited number of high-priority routes and to concentrate on improving them with federal-aid funds. At the same time, these states can incorporate design and construction improvements that address their traffic needs safely and efficiently. States can make operational changes, such as a program to locate and remove stalled vehicles that are impeding smooth traffic flow. States can employ available technological improvements, such as Intelligent Transportation Systems, which is intended to help reduce congestion and keep traffic moving without major roadway expansion.

NHS is intended to be a unified system where each mode complements the other. Increasingly, intermodal carriers rely on all forms of transportation to deliver goods and services to consumers in the most efficient manner possible. NHS supports this goal by serving 198 ports, 207 airports, 67 Amtrak stations, 190 rail/truck terminals, 82 intercity bus terminals, 307 public transit stations, 37 ferry terminals, 58 pipeline terminals, and 20 multipurpose passenger terminals.



Source: http://en.wikipedia.org/wiki/National_Highway_System_(United_States) - Accessed 2010

Figure 2-2: National Highway System of the United States of America

2.3.1.2 Europe

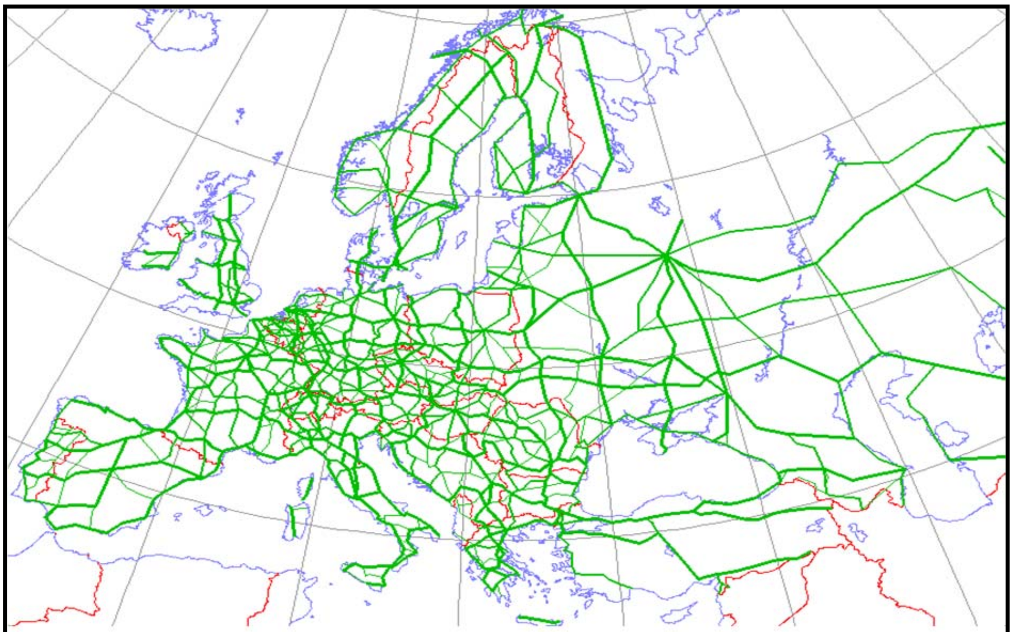
The international E-Road Network (Euro-Route) is a numbering system for roads in Europe developed by the United Nations Economic Commission for Europe (UNECE) (refer to Figure 2-3). The network is numbered from E1 up and its roads cross national borders. It also reaches Central Asian countries like Kyrgyzstan, since they are members of the UNECE.

In most countries, roads carry the European route designation beside national road numbers. Other countries like Belgium, Denmark, Norway and Sweden have roads with exclusive European route signage (examples are the E18 and E6).

Road Design Standards of E-Road Network

The following design standards are applied to Euro-Routes unless there are exceptional circumstances (such as mountain passes etc):

- Built-up areas shall be by-passed if they constitute a hindrance or a danger
- The roads should preferably be motorways or express roads (unless traffic density is low so that there is no congestion on an ordinary road)
- They should be homogeneous and be designed for at least 80km/h (very exceptionally 60km/h) with Motorways designed for at least 100km/h
- Gradients should not exceed 8% on roads designed for 60km/h, decreasing to 4% on roads designed for 120km/h
- The radius of curved sections of road should not exceed 120m on roads designed for 60 km/h rising to 1 000m on roads designed for 140km/h
- ‘Stopping distance visibility’ should be at least 70m on roads designed for 60 km/h, rising to 300m on roads designed for 140km/h
- Lane width should be at least 3.5m on straight sections of road
- The shoulder is recommended to be at least 2.5m on ordinary roads and 3.25m on motorways
- Central reservations should be at least 3m unless there is a barrier between the two carriageways
- Overhead clearance should be not less than 4.5m
- Railway intersections should be at different levels.



Source: http://www.search.com/reference/International_E-road_network - Accessed 2010

Figure 2-3: E-Road Network of Europe

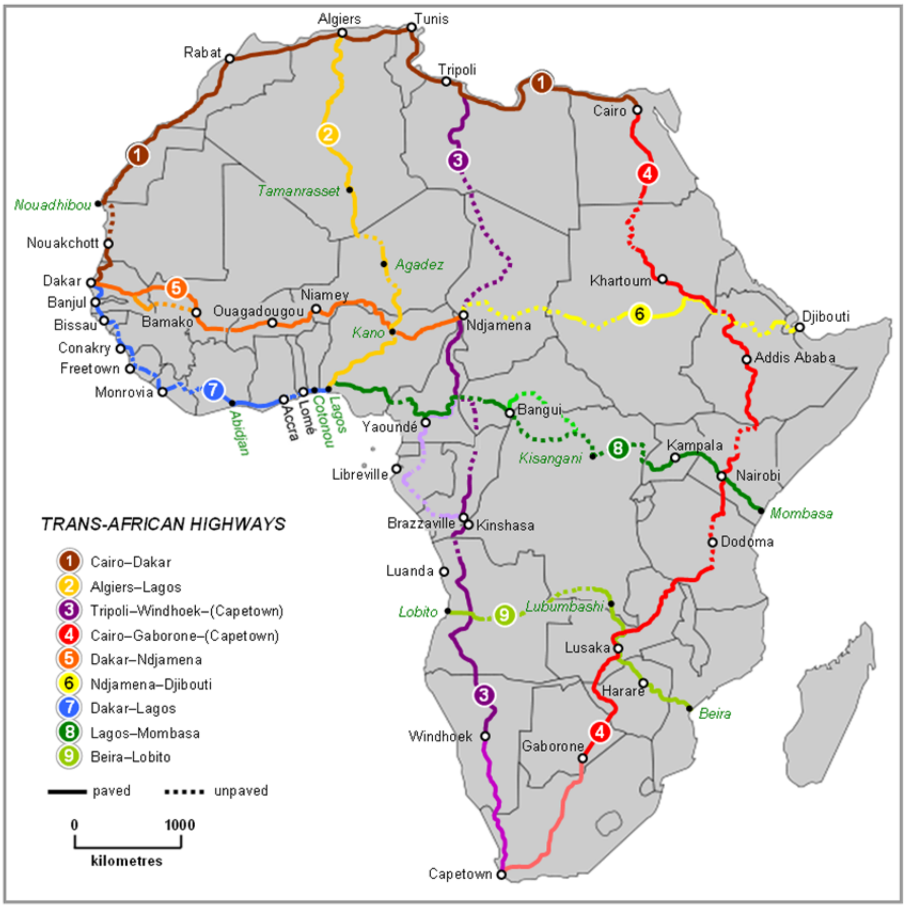
2.3.1.3 Africa

The Trans-African Highway Network comprises transcontinental road projects in Africa being developed by the United Nations Economic Commission for Africa (UNECA), the African Development Bank (AfDB), and the African Union in conjunction with regional economic communities (refer to Figure 2-4). They aim to promote trade and alleviate poverty in Africa though highway infrastructure development and the management of road-based trade corridors. The total length of the nine highways in the network is about 57 000km.

In some documents the highways are referred to as 'Trans-African Corridors' or 'Road Corridors' rather than highways. The name Trans-African Highway and its variants are not widely used outside of planning and development circles, and currently one does not see them signposted as such or labelled on maps, except in Kenya and Uganda where the Mombasa-Nairobi-Kampala-Fort Portal section (or the Kampala-Kigali feeder road) of Trans-African Highway 8 is sometimes referred to as the 'Trans-Africa Highway'.

The network as planned reaches all the continental African nations except Burundi, Eritrea, Somalia, Equatorial Guinea (Rio Muni), Lesotho, Malawi, Rwanda and Swaziland. Of these, Malawi, Lesotho and Swaziland have paved highways connecting to the network, and the network reaches almost to the border of the others.

The agencies developing the highway network subscribe to the understanding that road infrastructure stimulates trade and so alleviates poverty, as well as benefiting health and education since they allow medical and educational services to be distributed to previously inaccessible areas.



Source: http://en.wikipedia.org/wiki/Trans-African_Highway_network - Accessed 2010

Figure 2-4: The Trans-African Highways Network

2.4 The Need for an EAC Regional Road Network Classification

In the EAC, uniformity of road classification practice will be of value in meeting the expectations of a rapidly growing and increasingly mobile driver population as well as improving, sustaining and supporting social and economic development within the EAC.

The increase in mobility has resulted in an increase in cross-border traffic, implying a greater need than before for uniformity in road classification and standardisation of roads that play such a function between the member states of the EAC.

The EAC regional corridors and the national primary road networks provide the foundation for developing a special road classification specific to the needs of the EAC and its member states.

2.4.1 Characteristics of an EAC Regional Road Network Classification

In light of international best practice, the proposed EAC regional road classification could have the key characteristics as shown below. The precise calibration of these characteristics should be the subject of a focused discussion between Member States and the values shown here are therefore indicative only:

- Link major cities and locations (e.g. ports, border controls, etc.)
- The roads should preferably be of a high-order freeway, highway or motorway design standard (in terms of pavement, median separated, width, etc. determined by traffic volume)
- They should be homogeneous and be designed for at least 80km/h (very exceptionally 60km/h) with Motorways designed for at least 100km/h
- They should be numbered in line with international best practice (e.g. the European E-Road Network is numbered E followed by a numerical number)
- Gradients should not exceed 8% on roads designed for 60km/h, decreasing to 4% on roads designed for 120km/h traffic
- On major roads and freeways, the minimum curve length in metres should be three times the design speed (km/h).
- Stopping Sight Distance (SSD) visibility should be at least 300m
- Lane width should be at least 3.5m on straight sections of road
- The shoulder is recommended to be at least 2.5m on ordinary roads and 3.25m on motorways
- Central reservations should be at least 3m unless there is a barrier between the two carriageways – whereas the central reservation width would be the width of the barrier
- Overhead clearance should be not less than 4.5m
- Railway intersections should be grade separated.

2.4.2 Recommended EAC Regional Road Classification and Numbering

Given the abovementioned it is clear that by developing an overarching, high-order and integrated road classification and numbering system unique to the EAC, which is based on international best practice, would solidify the identified importance and function of the EAC road corridors and furthermore strengthen and support economic development.

Table 2-11 and Table 2-12 provides for a proposed EAC regional road classification and numbering system. A visual representation is also provided for in Map 2-2.

Table 2-11: EAC Corridor Road Classification and Numbering

EAC Road Number	Function	EAC Road Corridor Name	Length
EA1	**HIGH MOBILITY – Class 1 Movement is dominant, through traffic is dominant, the majority of traffic does not originate or terminate in the immediate vicinity, the function of the road is to carry high volumes of traffic between urban districts, across and through Member States; connecting Member States; Freight focused and Freight supportive;**	Northern Corridor	1 900km
EA2		Central Corridor	3 100km
EA3		Dar es Salaam (TAZARA) Corridor	1 100km
EA4		Namanga Corridor	1 800km
EA5		Sumbawanga Corridor	1 300km
EA6		Sirari Corridor	1 500km
EA7		Coastal Corridor	1 500km
EA8		Mtwara Corridor	800km
EA9		Arusha Corridor	500km
EA10		Gulu Corridor	600km
TOTAL			**14 100km**

Source: Africon calculations and recommendations based on international best practice

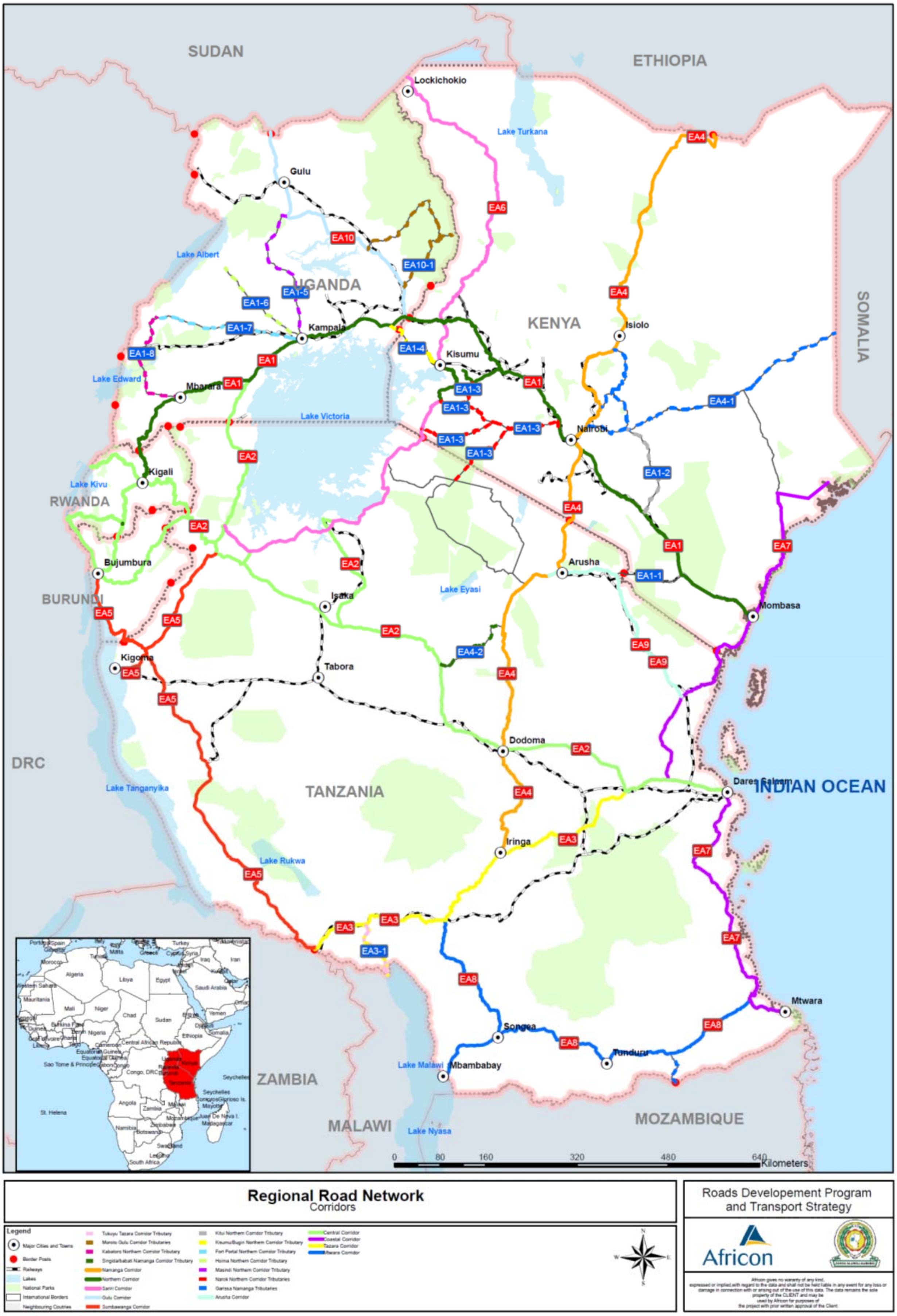
Note: All lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 2-12: EAC Corridor Feeder Road Classification and Numbering

EAC Road Number	Function	EAC Corridor Feeder Name	Length
EA1-1	**HIGH MOBILITY – Class 2 Class 2 Corridor Feeder Roads with its main function that of Supporting the EAC Corridors (Class 1 Roads)**	Taveta/Voi Northern Corridor Feeder	150km
EA1-2		Kitui Northern Corridor Feeder	200km
EA1-3		Narok Northern Corridor Feeders	900km
EA1-4		Kisumu/Bugiri Northern Corridor Feeder	150km
EA1-5		Masindi Northern Corridor Feeder	300km
EA1-6		Hoima Northern Corridor Feeder	200km
EA1-7		Fort Portal Northern Corridor Feeder	300km
EA1-8		Kabatoro Northern Corridor Feeder	250km
EA3-1		Tukuyu Dar es Salaam (TAZARA) Corridor Feeder	150km
EA4-1		Garissa Namanga Corridor Feeder	1 250km
EA4-2		Singida/Babati Namanga Corridor Feeder	200km
EA10-1		Moroto Gulu Corridor Feeder	400km
TOTAL			**4 450km**

Source: Africon calculations and recommendations based on international best practice

Note: All lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.



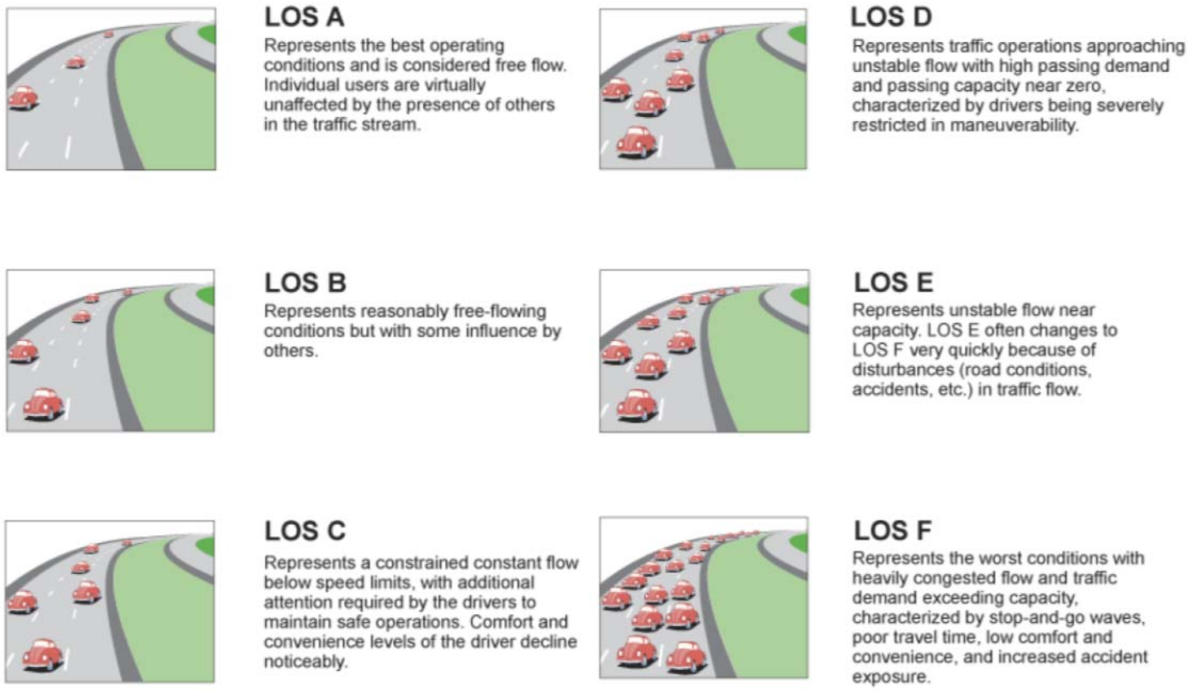
Map 2-2: Proposed EAC Corridor and Corridor Feeder Road Classification and Numbering

3. ANALYSIS APPROACH

3.1 Concept of 'Level of Service'

Level of Service (LOS) analysis is an internationally recognised approach for benchmarking the capacity of transportation infrastructure (facility) such as roadways, intersections, footways, etc. in terms of its operational conditions within a traffic stream, measured in terms of outputs such as speed and travel time, freedom to manoeuvre, traffic interruptions, comfort, and convenience, that it is and could be providing, for its users (pedestrians, drivers, cyclists, etc.).

The Highway Capacity Manual (HCM) defines LOS as: *'A qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed and travel time, freedom to manoeuvre, traffic interruptions, comfort, and convenience.'* (HCM, 2000).



Source: www.route228.com/virtMtg/elements/LOS.gif

Figure 3-1: Highway LOS Range

The key performance indicator that is used to evaluate the status of vehicular operations on a roadway is therefore expressed in terms of a Level of Service (LOS). LOS is indicated by using the letters of the alphabet ('A' through to 'F'), 'A' representing the best operating conditions and 'F' the worst. When new road infrastructure is designed, most public sector entities tend to require a design LOS of at least 'C' in the design year – in other words, if a facility is designed to last for a period of seven years, in year seven the facility should preferably still operate at a LOS of 'C'. The reality within most countries, however, is at a level that is usually substantially lower than this ideal situation, especially in and around urban environments.

The LOS is determined by using different approaches as recommended by the HCM. For two-lane and multi-lane freeways, the approaches to measure LOS differ but provide the practitioner with results that are comparable.

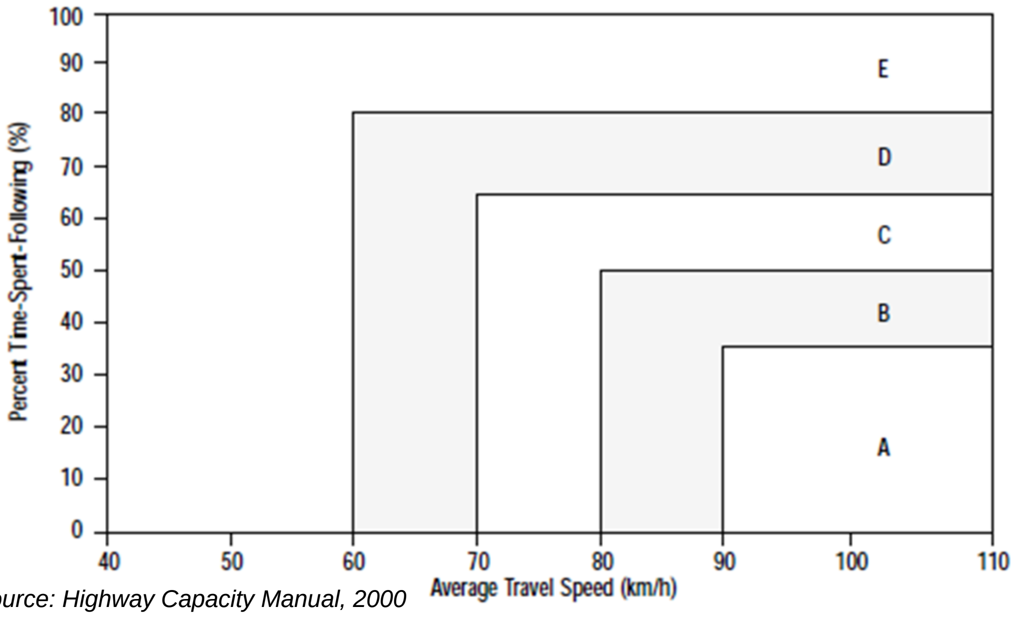
- Two-lane facilities

  LOS is determined in terms of both *percentage time-spent-following* and *average travel speed*. These two factors provide a representative measure of the efficiency of mobility. The worst of the two measures is taken as representative of the facility.

- Multi-lane facilities

LOS is determined as a relationship between the *average passenger-car speed* and the *traffic density*. It provides an indication of the freedom of a vehicle to manoeuvre within the traffic stream as well as the vehicle's proximity to other vehicles.

Figure 3-2: Multi-lane Facility



Source: Highway Capacity Manual, 2000

Figure 3-3: Level of Service Criteria for Two-Lane Highways

3.2 Interface of Condition vs Capacity vs Traffic

The interface between the physical road condition, the capacity of a roadway segment and the traffic volume is discussed in this section. The following general definitions are important as a point of departure (Highway Capacity Manual, 2000):

- **Capacity** - The maximum sustainable flow rate at which vehicles or persons reasonably can be expected to traverse a point or uniform segment of a lane or roadway during a specified time period under given roadway, geometric, traffic, environmental, and control conditions; usually expressed as vehicles per hour, passenger cars per hour, or persons per hour
- **Density** - The number of vehicles on a roadway segment averaged over space, usually expressed as vehicles per kilometre or vehicles per kilometre per lane
- **Flow rate** - The equivalent hourly rate at which vehicles, bicycles, or persons pass a point on a lane, roadway, or other traffic way; computed as the number of vehicles, bicycles, or persons passing the point, divided by the time interval (usually less than 1 h) in which they pass; expressed as vehicles, bicycles, or persons per hour
- **Free flow** - A flow of traffic unaffected by upstream or downstream conditions
- **Free-flow speed** - (1) The theoretical speed of traffic, in kilometres per hour, when density is zero, that is, when no vehicles are present; (2) the average speed of vehicles over an urban street segment without signalised intersections, under conditions of low volume; (3) the average speed of passenger cars over a basic freeway or multilane highway segment under conditions of low volume
- **Speed** - A rate of motion expressed as distance per unit of time
- **Travel speed** - The average speed, in kilometres per hour, of a traffic stream computed as the length of a highway segment divided by the average travel time of the vehicles traversing the segment
- **Road Condition** - The surface condition of paved roads deteriorates over time (refer to Figure 3-4 below). Road condition also provides details regarding the ride quality of a specific road segment and has a direct impact on safety and the speed at which one can travel.

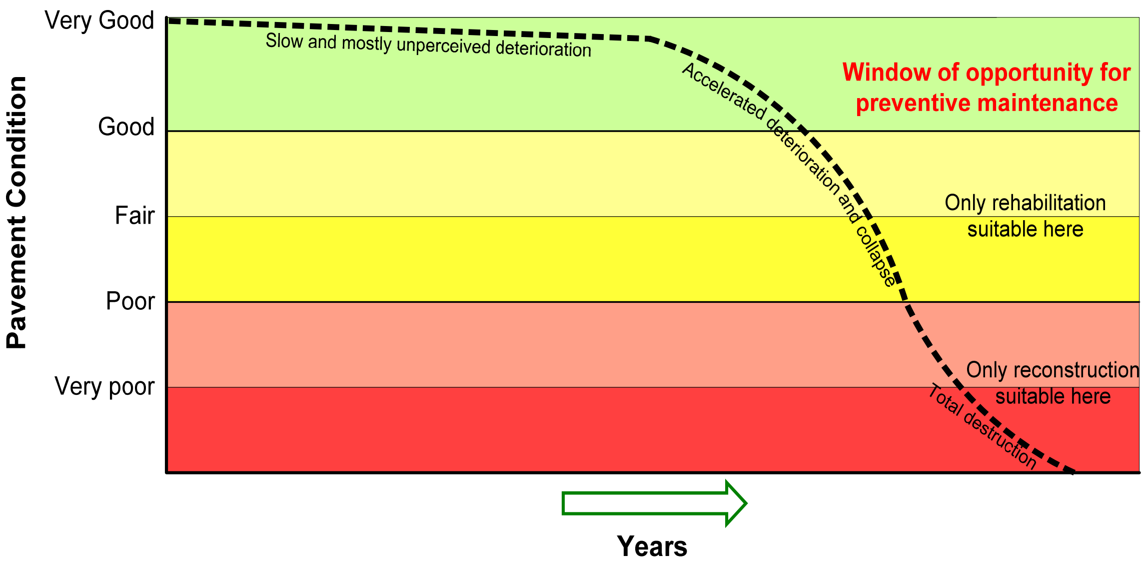
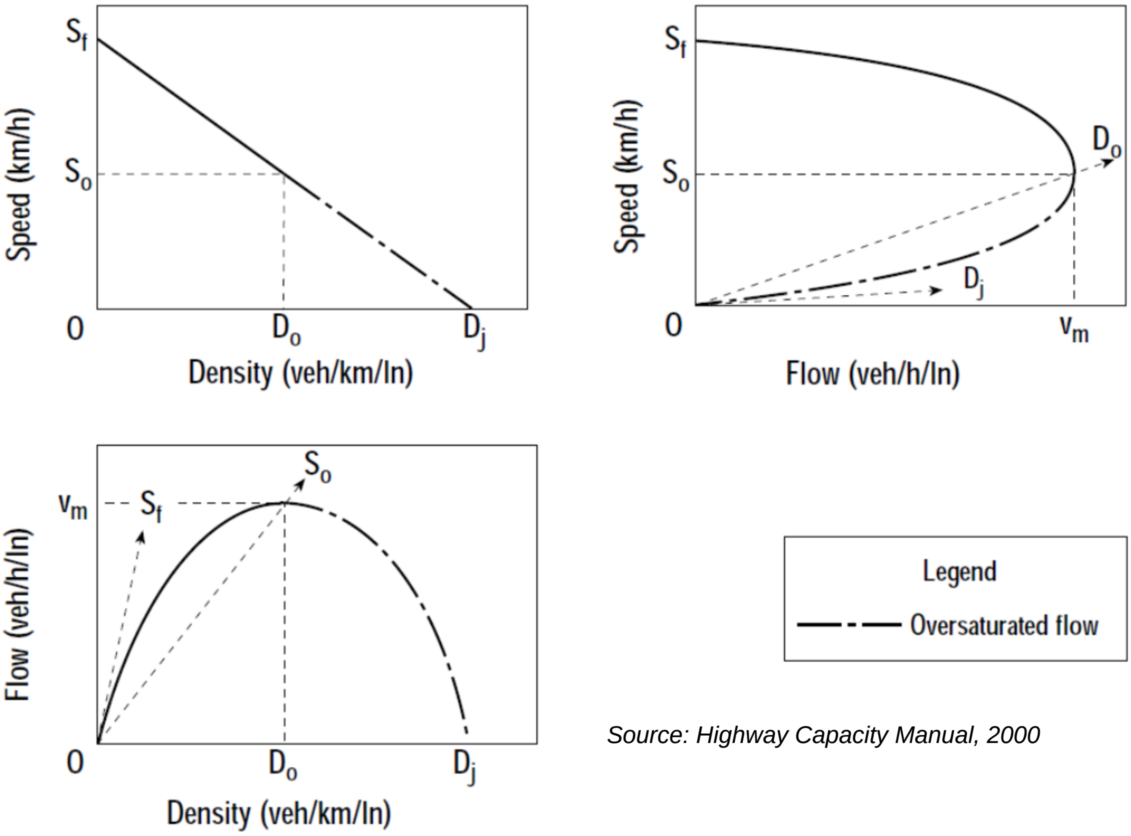


Figure 3-4: Time vs. Deterioration of Roads

Figure 3-5 below illustrates the speed-density, flow-density, and speed-flow relationships on uninterrupted-flow facilities (highways) and are the basis for analyzing capacity of uninterrupted-flow facilities.

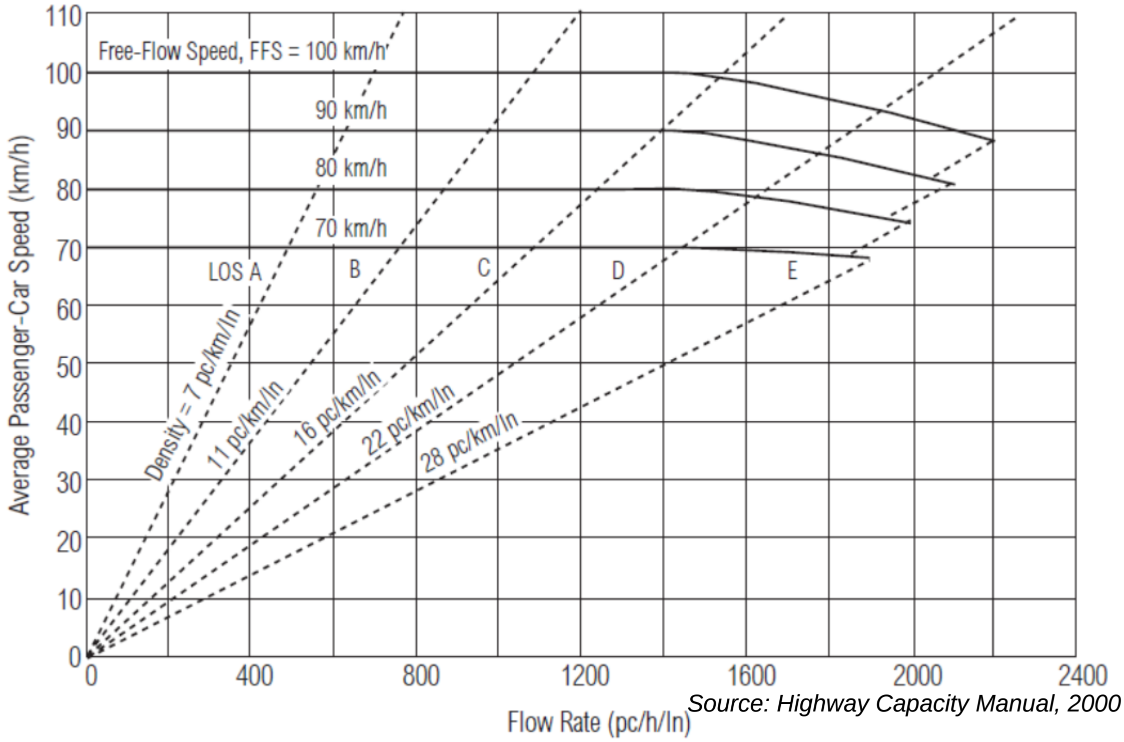
Simply put, as density approaches zero (light traffic), speed increases and flow approaches zero. Similarly, as density increases (heavy traffic) speed is reduced and flow is increased until it reaches a point called jammed density where all vehicles have stopped and flow is zero.



Source: Highway Capacity Manual, 2000

Figure 3-5: Generalised Relationship among Speed, Density, and Flow Rate on Uninterrupted-Flow Facilities (Highways)

Figure 3-6 below demonstrates the speed-flow relationship with LOS criteria.



Source: Highway Capacity Manual, 2000

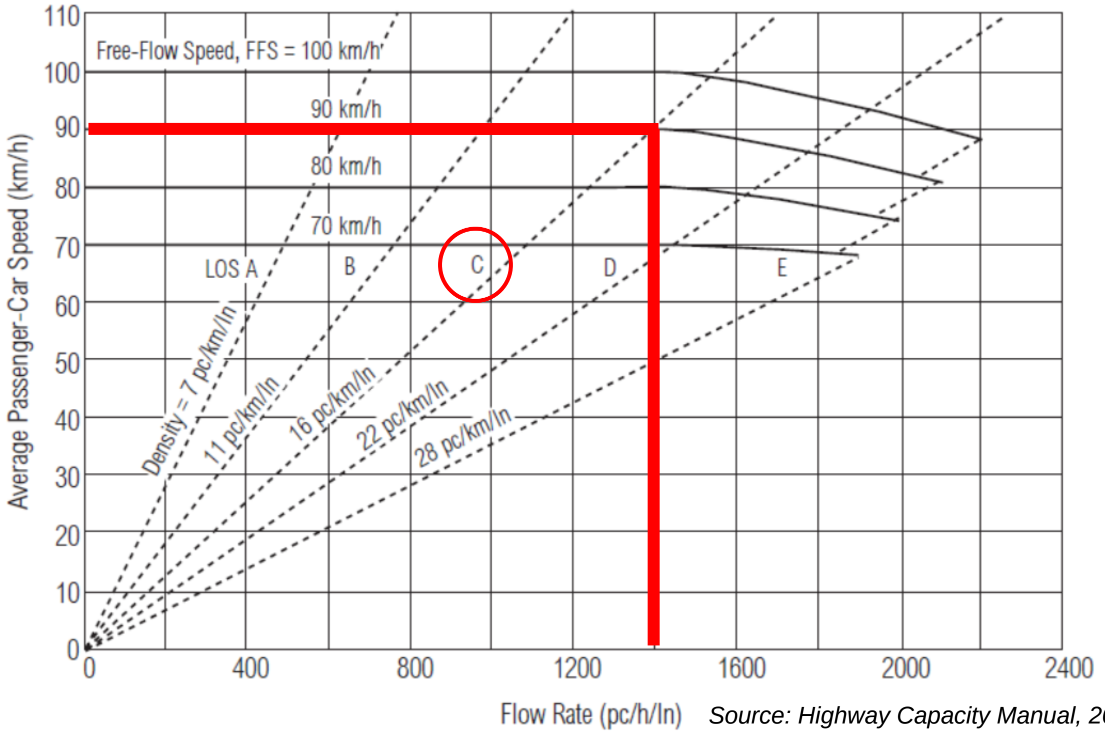
Figure 3-6: Speed-Flow Curves with LOS Criteria

Road condition, in terms of the ride quality of a road, is also an important factor that has an impact on the speed that a vehicle can travel. In other words, the poorer the ride quality/road condition of a roadway segment, the lower the speed one is able to travel.

This can be demonstrated by looking at the following situation: a road segment is categorised as having a LOS C with a free-flow speed of 90km/h and a flow rate of 1 400 passenger cars per hour per lane (pc/h/ln) and a density of 16 pc/km/ln (refer to Figure 3-7) under acceptable road conditions.

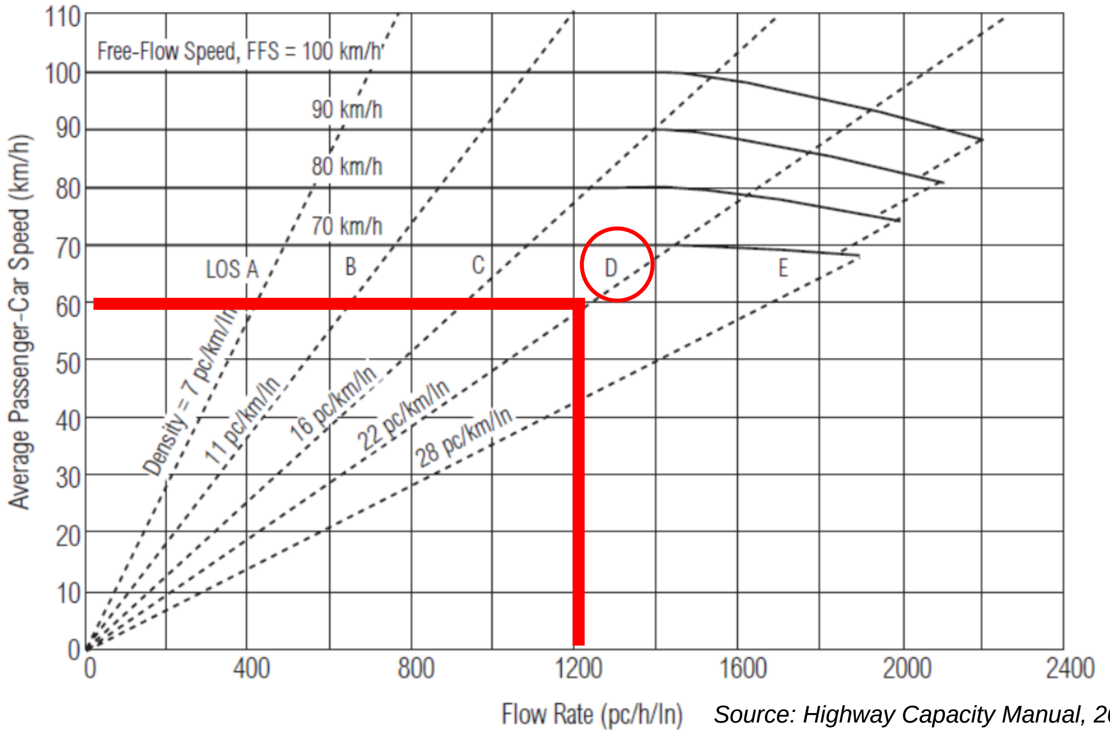
However, should one take into account the impact of very poor road condition and ride quality on the same road segment, the LOS would diminish as a result. Therefore, with reference to Figure 3-8 below, the same road segment which should have a LOS C under acceptable road conditions, would in fact have a LOS D under poor road and ride quality conditions as a result of a reduced free-flow speed of 60km/h, an increased density of 22pc/km/ln and a reduced flow rate of 1200pc/h/ln.

Therefore, there is a direct correlation between road condition/quality and free-flow speed and these are important criteria for the successful assessment of a road network which were taken into account during this study.



Source: Highway Capacity Manual, 2000

Figure 3-7: LOS C – Free-Flow Speed 90km/h and Flow Rate of 1400pc/h/ln



Source: Highway Capacity Manual, 2000

Figure 3-8: LOS D – Free-Flow Speed 70km/h and Flow Rate of 1 200pc/h/ln

3.3 Standardisation of Network for Condition, Traffic and Capacity Analyses

Figure 3-9 below demonstrates the relationship between the Highway Design and Maintenance Model (HDM); the First Order Network Analysis (FONA) Model; and the Transport Model developed for the EAC Transport Strategy and Regional Roads Sector Development Program. In the context of the discussion under the previous section (Interface of Condition vs Capacity vs Traffic), the HDM model is where road condition is assessed, the FONA model captures road capacity and the Transport Model is where traffic projections are made.

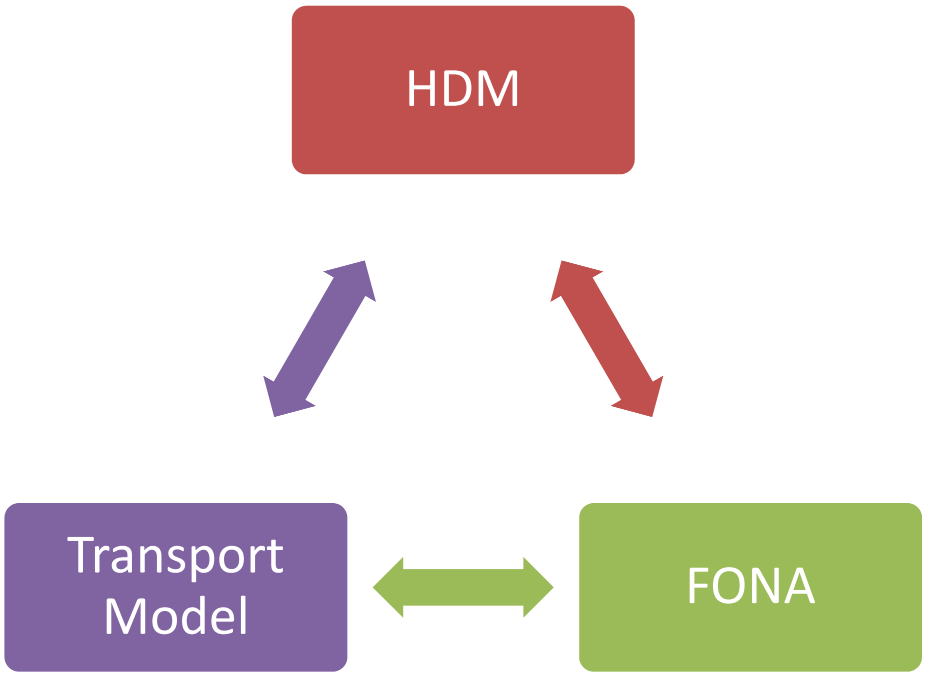


Figure 3-9: Relationship between the HDM Model; FONA and the Transport Model

The EAC Network data was standardised in order to be applied in all three model platforms in order to provide consistent analysis input/output in terms of condition, traffic and capacity analysis. Therefore the data that was utilised for the HDM analysis was also utilised for the Transport Model as well as for FONA.

3.4 Traffic Scenarios

Three traffic growth scenarios were developed for the EAC Transport Strategy and Regional Roads Sector Development Program, namely:

- 2010 Base Year Scenario
- 2020 Target Year – Conservative Traffic Growth Scenario
- 2020 Target Year – Optimistic Traffic Growth Scenario.

In the absence of land use projections spanning the study period, it is considered standard practice to utilise projected GDP growth rates as a proxy for future traffic growth. As discussed in more detail in Part I, the EAC economies are projected to grow realistically at 5%/annum or more optimistically at 8%/annum.

It is usually expected that traffic growth would exceed GDP, by up to a factor of two (i.e. traffic growth could be double the GDP growth rate). To calibrate the GDP-traffic relationship, comprehensive traffic counts are required, i.e. traffic counts that are taken all year round at fixed locations and enable a year-by-year assessment.

In the case of the EAC, there is an absence of reliable data showing historical road traffic growth (the dominant regional transport mode). An analysis of historical traffic counts at recurring counting stations shows high variances in growth rates, pointing to a combination of unreliable or un-standardised data and/or very variable growth. The median growth rate is 1%/annum and the average 13%/annum. Given the statistical paucity of the data, the realistic and optimistic economy growth rates which fall between these two measures appear to be an adequate proxy for traffic growth, i.e. an additional traffic growth factor is not applied over and above GDP growth.

The following traffic growth rates were developed and represent each traffic scenario:

Table 3-1: Traffic Growth Rates per Scenario

Traffic Scenario	Traffic Volume	Traffic Growth Rate
2010 Base Year	Base year traffic volumes assuming ideal road conditions	
2020 Realistic	Base volume with compound growth rate of average EAC GDP projected growth rate, assuming ideal road conditions	5%/annum
2020 Optimistic	Base volume with compound growth rate of average EAC GDP growth rate times 1.6, assuming ideal road conditions	8%/annum

Source: Africon, 2010

The traffic scenarios developed are summarised in the following table:

Table 3-2: Traffic Scenarios Developed for the EAC Transport Strategy and Regional Roads Sector Development Program

Traffic Scenarios	Target LOS	Crawling Heavy Vehicles	Accuracy Assumption
2010 Base Year	D	30%	Very Fine – 1 vehicle increment
2020 5% Growth			
2020 8% Growth			

Source: Africon, 2010

3.5 Interface of Roads Capacity Assessment, Transport Model and Condition Assessment

The Transport Model ('VISUM) is utilised across all transport modes to assess the relationship between traffic and infrastructure capacity, i.e. it identifies where actual or projected traffic does or is likely to exceed the infrastructure's ability to process that traffic at an acceptable level of service. In the case of roads, the high-level assessment carried out by means of the Transport Model is refined by applying the more detailed First Order Network Assessment (FONA) model.

Table 3-3 below demonstrates the interface between the roads capacity assessment (FONA) and the Transport Model.

Table 3-3: Interface of Roads Capacity Assessment (FONA) and Transport Model

Comparator	FONA	Transport Model (VISUM)
Focus	Roads Operational	All Modes (roads, rail, air, pipeline, etc.) Strategic
Input	30th highest Traffic Volume Network Constraints	Land Use, Socio-economic Data Network capacity
Output	LOS	Traffic Volumes Desire Lines volume-Capacity Ratios
Growth	Compound (static value)	Mode zone specific – linked to land use / socio-economic (dynamic)
Network	Existing links	Existing and new links
Assignment of traffic	No assignment of traffic	Yes (assignment of traffic)

Source: Africon, 2010

3.6 Treatment of New Links

FONA only investigates and assesses existing road links based on traffic (demand) flows without traffic assignment.

The Transport Model, however, analyses new road links based on land use and other socio-economic data utilised to generate traffic. Traffic is assigned to new links based on the aforementioned analysis.

Therefore, both the Transport Model and FONA facilitate data transfer which in turn enables superior road network analysis.

4. MODEL DATA

Information relating to the current traffic volumes, traffic composition, and road network geometry are required in order to determine the current capacity and condition of the identified road corridors within the EAC.

As previously mentioned the FONA model was used to determine the capacity of the road network corridors of the EAC, along with inputs from the strategic transport model, and the HFM-4 model was used to assess road network condition.

To populate the models with acceptable data for the primary road network corridors, the following information collection, validation, parameter calculation and model population process was followed. The process is illustrated in Figure 4-1 below and forms the outline of this Section.

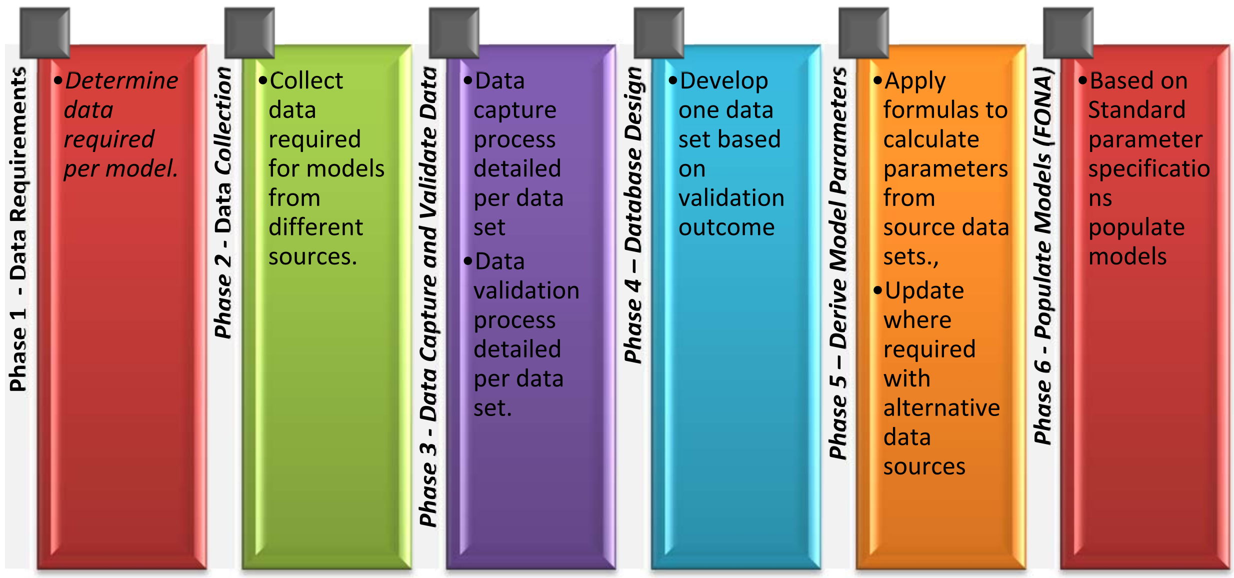


Figure 4-1: Information Collection and Model Populate Process

4.1 Phase 1 – Data Requirements

The models (FONA, HDM-4 and VISUM) required a vast number of traffic volume data, composition parameters, and road infrastructure information to calculate the LOS, V/C ratios and condition indices of the Road Network Corridors of the EAC. The required model parameters were used to set out the **data requirement specification** which guided the request for secondary data and the collection of primary data throughout the development of the models. Furthermore, it was also important to understand the calibration requirements of the various models in order to streamline the process.

Once the data requirements were determined the secondary data sets (i.e. traffic volumes, network characteristics, network geometry, etc.) available from the EAC Member States were analysed to determine the extent of secondary data gaps in order to plan the primary data collection of the project.

4.2 Phase 2 – Data Collection

The data collection process was guided by the data requirement specification. The data collection processes was mitigated with the identification of available data sources and identifying shortcomings (gaps) that needed to be augmented through primary data surveys. The data collection process and validation of existing secondary data sets is illustrated in Figure 4-2 below.

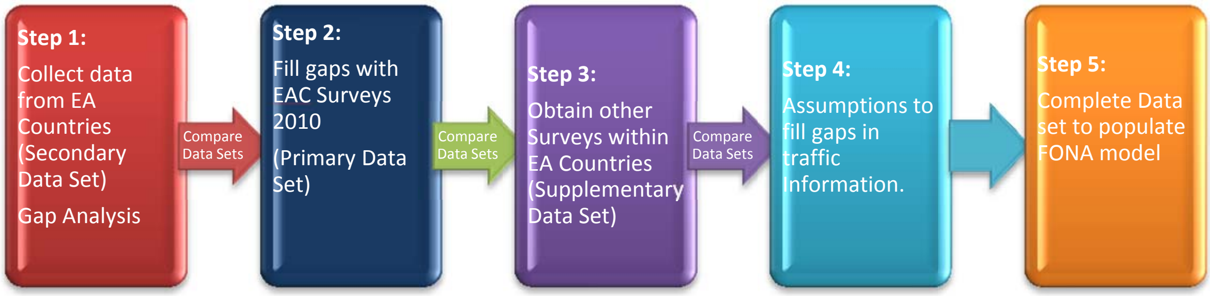


Figure 4-2: Data Collection and Development of One Data Set Process

Three main data sources were identified to obtain traffic and network geometry information. These sources were:

- East Africa Community (EAC) Member States roads agencies (secondary data set)
- Other consultants carrying out projects within the EAC (supplementary data set)
- New surveys for validation purposes completed in 2010 as part of this project (primary data).

The data from the EAC countries was collected in two stages, namely:

- Site visits were conducted within the EAC Member States during early 2009 when available data from all the member countries were obtained. This data was compared with the data requirement specification and gaps in the data set was identified
- The gaps identified in the secondary data set were forwarded to the Member States in order to source supplementary data where available. Supplementary data collected from existing sources was provided to the team during the workshop in Arusha (April 2010). This data was added to the final data set.

The data received from the EAC Member States can be divided into two components:

- **Traffic Information (demand) data** (traffic volumes (ADT), origins and destinations (OD)). The data was provided in various formats ranging from Excel, text format, MS Access and Adobe (pdf)
- **Road infrastructure (supply) data** (road alignment (GIS), number of lanes per road link, count station location, road condition). The data was provided in various formats ranging from Geographic Information System (GIS) files, Excel files, and MS Access database files. These files hosted the attributes relating to the road infrastructure as well as the physical location of the road link.

Table 4-1 shows the traffic information received per data requirement specification category from each EAC Member State. It was noted that several of the countries do not have traffic counting programs and limited traffic data was therefore available. Table 4-2 indicates information relating to the road infrastructure and spatial data received per EAC Member State. The lack of detail pertaining to the road infrastructure was identified as a major concern.

Based on the tables below it was noted that limited model parameter data was available in Rwanda, Burundi and Kenya. These areas required the identification of supplementary data sources and data collection processes in order to augment the secondary data sets.

It was furthermore found that the national roads agencies do not record origin and destination information whilst this is required for the purpose of the VISUM model calibration and model set-up. This need was addressed through origin-destination surveys at strategic locations along the EAC primary road network. These surveys were transformed into matrices for the VISUM model.

The overall purpose of conducting primary traffic counts was to provide and fill the gaps in the current traffic data and to ensure that the data meet the requirements of the FONA, HDM and VISUM models.

Table 4-1: Traffic Information Received per EAC Member State (2010)

Member State	>2 years counts per station	Base Year of Counts	Count Duration	Growth Rate	Classified Counts	Link to GIS shape file	GPS Location	OD's
Tanzania	Yes	2004-2008	4 -12 hour	No	Yes	Yes	Yes	No
Kenya	No	2008	Yes	No	No	No	No	No
Uganda	No	2004	Yes	No	Yes	Yes	Yes	No
Rwanda	No	-	-	No	No	No	No	No
Burundi	No	2000	4-24 Hour	Yes (6%)	No	Partially	No	No

Source: EAC Member States, 2010

Table 4-2: Road Infrastructure Data

Country	Shape File	Terrain/ Urban/ Rural areas	Number of lanes/ Median	Shoulder width	Road surface	Speed	Passing opportunities	Number of Accesses
Tanzania	Yes	No	No	Yes	No	No	No	No
Kenya	Yes							
Uganda	Yes							
Rwanda	Yes							
Burundi	Yes							

Source: EAC Member States, 2010

4.3 Phase 3 – Data Capturing and Validation Process

The development of a traffic information and road geometry database and the data capturing process, is demonstrated in Figure 4-4 below. The application of this process to the three data sets is detailed subsequently.

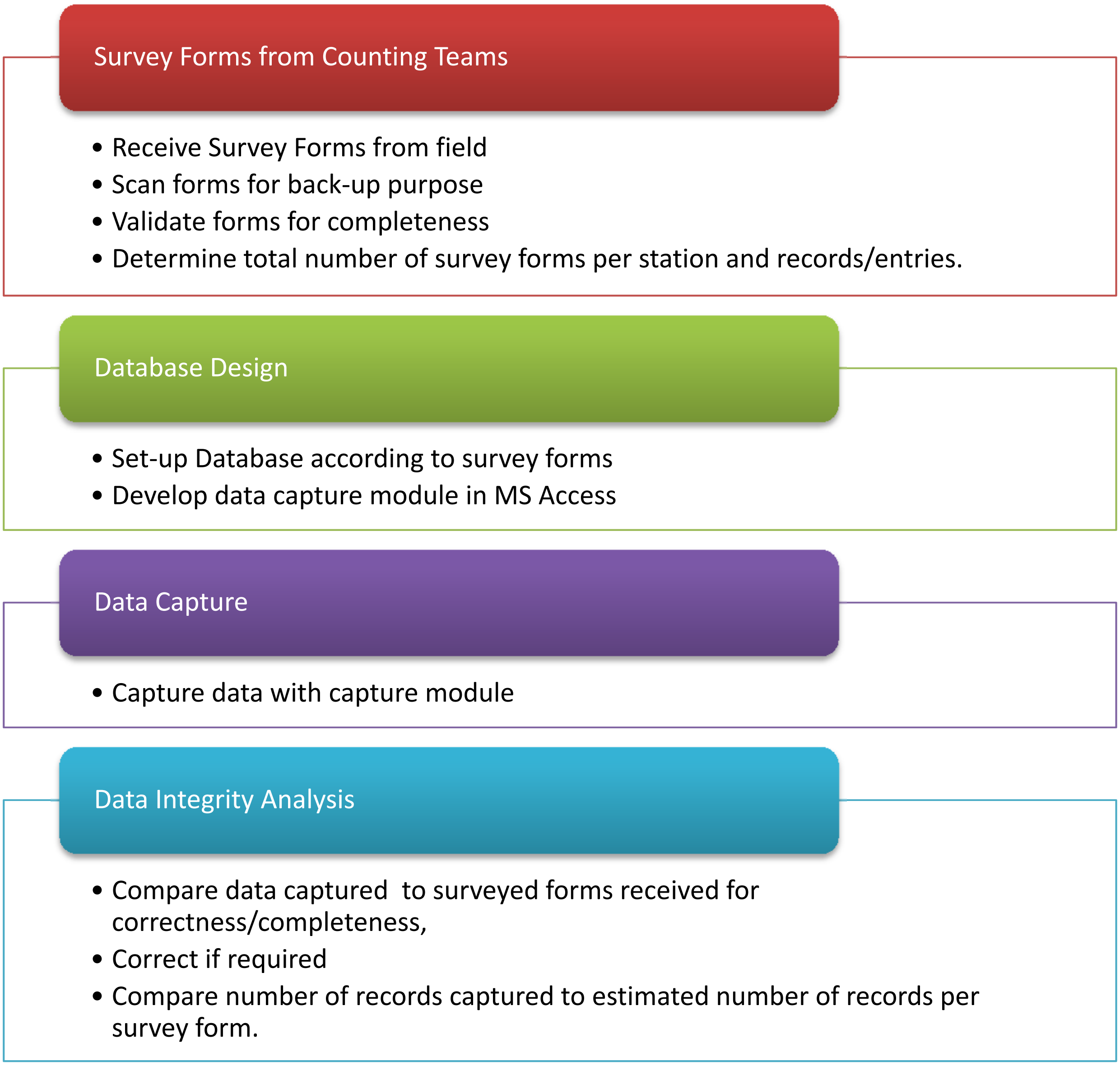


Figure 4-3: Data Processing and Analysis Process

4.3.1 Secondary Data Set

The secondary data from the Member States was received in various electronic formats. The majority of the countries provided the traffic counts in Excel format. These spreadsheets contained the classified traffic counts (i.e. ADT) with an attribute field that contained the spatial coordinates of the counting stations. These data fields enabled the linking of traffic counting information to the road link shape files provided by the Member States.

The traffic information received from the Member States had to be formatted as per the model requirements. The data received needed to align in terms of count duration, year of the counts and the vehicle classification system. The method followed to align the data set was as follows:

- <u>*Base Year –*</u> The base years varied from 2004 to 2008. The volumes needed to be projected to the project base year (2010). The traffic volumes were projected by applying a growth rate per year. A compound growth formula was used for the projection purposes.

$$y = (x) * (1 + r)^n$$
$$y = Projected\ traffic\ Volume$$
$$x = Current\ traffic\ Volume$$
$$r = Traffic\ Growth\ Rate$$
$$n = number\ of\ years\ differance\ between\ data\ counted\ and\ 2010$$

- *Traffic Volume Count Duration* – The duration of the traffic counts differed from 24 hour counts, Average Daily Traffic (ADT[1]) to Annual Average Daily Traffic (AADT[2]). Comparing the traffic volumes collected over different durations with each other can be misleading. However, after careful interrogation of the secondary traffic volumes through comparison with the primary data sources, it was concluded that the majority of the volumes were 24-hour (ADT) counts and, none of the volumes received were AADT. The 30th highest hourly volume was calculated by applying a K-factor in order to accommodate the traffic volumes in the FONA model. The HDM and VISUM models utilised the ADT volumes directly.
- *Vehicle Classification* – Tanzania and Uganda's counts were classified according to light and heavy vehicles, as well as bus and taxi. The heavy vehicles were classified into 6 or more heavy vehicle classes. Data received from Kenya, Rwanda and Burundi provided a total traffic volume, no distinction was made between vehicles types.
- *Growth Rate* – In order to project the traffic volumes received from the different countries a traffic growth rate per country was required. A traffic growth rate was calculated based on the traffic volumes collected on a year-on-year basis. The traffic volumes at specific locations were compared and the growth rate was calculated. Based on the assessment it was found that no counting programs are currently running on a year-to-year basis and a traffic growth rate could not be obtained and thus needs to be assumed. The best indicator for traffic volume growth is the growth in GDP. The GDP's of the countries were obtained and applied in the traffic volume projection. The GDP comparison between the countries is shown in previous sections.

The outcome of the above process was one database set comprising of the traffic volume and traffic composition information. The dataset was hosted in a MS Access Database. The ADT was projected to the base year 2010 for all the Member States. A k-factor was applied to the ADT data in order to calculate the 30th highest hourly volume. Given that the 30th highest hourly volume is primarily used as the design volume during road design.

4.3.2 Primary Data Set

The primary data set was used for three purposes:

- To fill the gaps in the secondary data set received from the EAC countries
- To validate data received from the EAC countries and other sources
- To develop Origin Destination information to validate Visum matrices.

The primary data set was developed through several surveys at strategic locations along the identified road network corridors of the EAC. A detailed process to capture, validate and summarise the data was required. The process applied to develop the primary data set is illustrated in Figure 4-4 below and is discussed individually in sections that follow.

[1] ADT is the average number of vehicles two-way passing a specific point in a 24-hour period, for a specific time of the year (i.e. Monday, last Friday of the month, etc.).

[2] AADT is the total volume of vehicle traffic of a highway or road for a year divided by 365 days. AADT is a useful and simple measurement of how busy the road is. It is also sometimes reported as "average annual daily traffic"

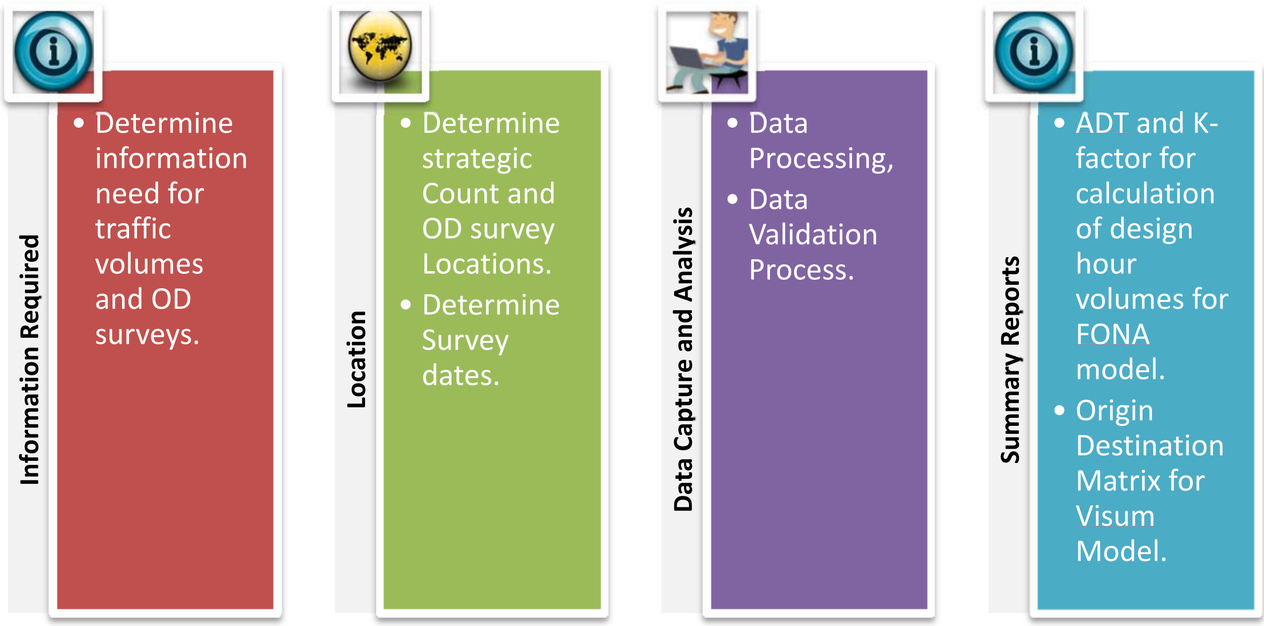


Figure 4-4: Primary Data Set Development Process

4.3.2.1 Information Requirements

Based on the assessment of the secondary data set and the resulting gapa analysis, two data categories were earmarked to be augmented with primary data surveys. These data categories were as follows:

- **Traffic volume and traffic composition information**. The data fields captured during the 12 hour surveys is shown in Figure 4-5 below
- **Origin-Destination (OD) information.** The data included origin, final destination, vehicle type, vehicle occupancy, cargo type and others. The survey forms used in the OD surveys indicating the detail information collected are shown in Figure 4-6 below.

MANUAL CLASSIFIED TRAFFIC VOLUME COUNT

Location: ______________________ **Date:** ______________________

Direction: ______________________ **Enumerator Name:** ______________________

Station: ☐☐

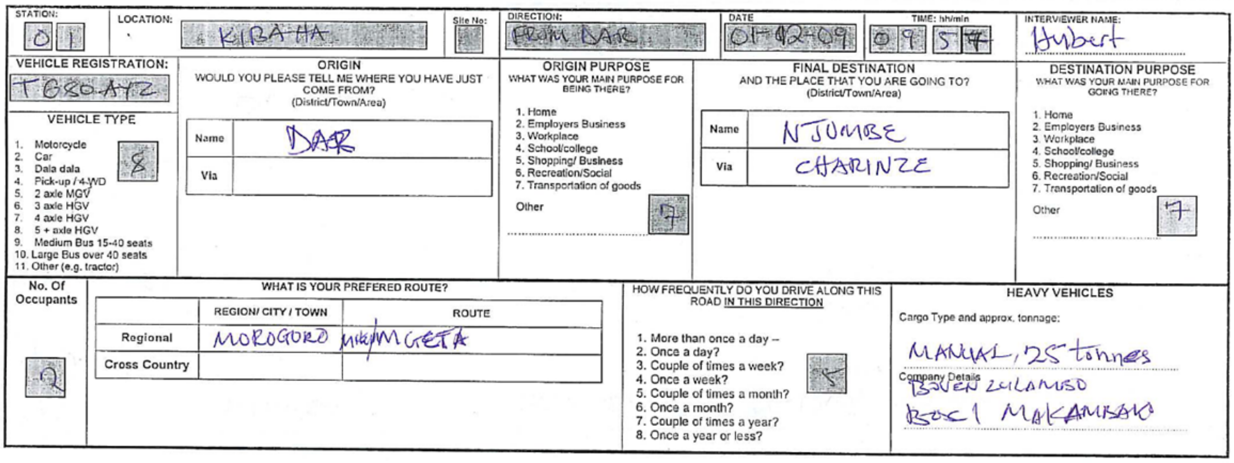
Sheet No.: ☐

Site No.: ☐☐

Time		Input Volumes (15 Minute Intervals)											
							HGV			Bus			
From	To	M/Cy	Car	Matatu	Pick Up / 4WD	2 Axle MGV	3 Axle	4 Axle	5 + Axle	Medium (15-40 seats)	Large (> 40 seats)	Other	TOTAL

Source: Developed by Africon, 2010

Figure 4-5: Traffic Count Survey Sheet



STATION: 01 | LOCATION: KIRAHA | Site No: | DIRECTION: FROM DAR | DATE: 01-02-09 | TIME: hh/mm 09 57 | INTERVIEWER NAME: Hubert

VEHICLE REGISTRATION: T680AYZ

VEHICLE TYPE: 8
1. Motorcycle
2. Car
3. Dala dala
4. Pick-up / 4-WD
5. 2 axle MGV
6. 3 axle HGV
7. 4 axle HGV
8. 5 + axle HGV
9. Medium Bus 15-40 seats
10. Large Bus over 40 seats
11. Other (e.g. tractor)

ORIGIN
WOULD YOU PLEASE TELL ME WHERE YOU HAVE JUST COME FROM? (District/Town/Area)
Name: DAR
Via:

ORIGIN PURPOSE
WHAT WAS YOUR MAIN PURPOSE FOR BEING THERE?
1. Home
2. Employers Business
3. Workplace
4. School/college
5. Shopping/ Business
6. Recreation/Social
7. Transportation of goods
Other: 7

FINAL DESTINATION
AND THE PLACE THAT YOU ARE GOING TO? (District/Town/Area)
Name: NJOMBE
Via: CHARINZE

DESTINATION PURPOSE
WHAT WAS YOUR MAIN PURPOSE FOR GOING THERE?
1. Home
2. Employers Business
3. Workplace
4. School/college
5. Shopping/ Business
6. Recreation/Social
7. Transportation of goods
Other: 7

No. Of Occupants: 2

WHAT IS YOUR PREFERED ROUTE?

	REGION/ CITY / TOWN	ROUTE
Regional	MOROGORO	MIKUMI GETA
Cross Country		

HOW FREQUENTLY DO YOU DRIVE ALONG THIS ROAD IN THIS DIRECTION: 5
1. More than once a day –
2. Once a day?
3. Couple of times a week?
4. Once a week?
5. Couple of times a month?
6. Once a month?
7. Couple of times a year?
8. Once a year or less?

HEAVY VEHICLES
Cargo Type and approx. tonnage: MANUAL, 25 tonnes
Company Details: [illegible] MAKAMBAKO

Source: Developed by Africon, 2010

Figure 4-6: Origin- Destination Survey Forms

4.3.2.2 Survey Locations

The locations of the traffic counts and OD surveys are shown in Map 4-1 below. The traffic count locations are indicated in yellow triangles and the OD survey locations in red circles.

In total, 16 traffic count locations were identified and surveyed and five origin-destination survey locations were identified and surveyed. The details regarding the number and duration of survey locations per Member State are shown in Table 4-3.

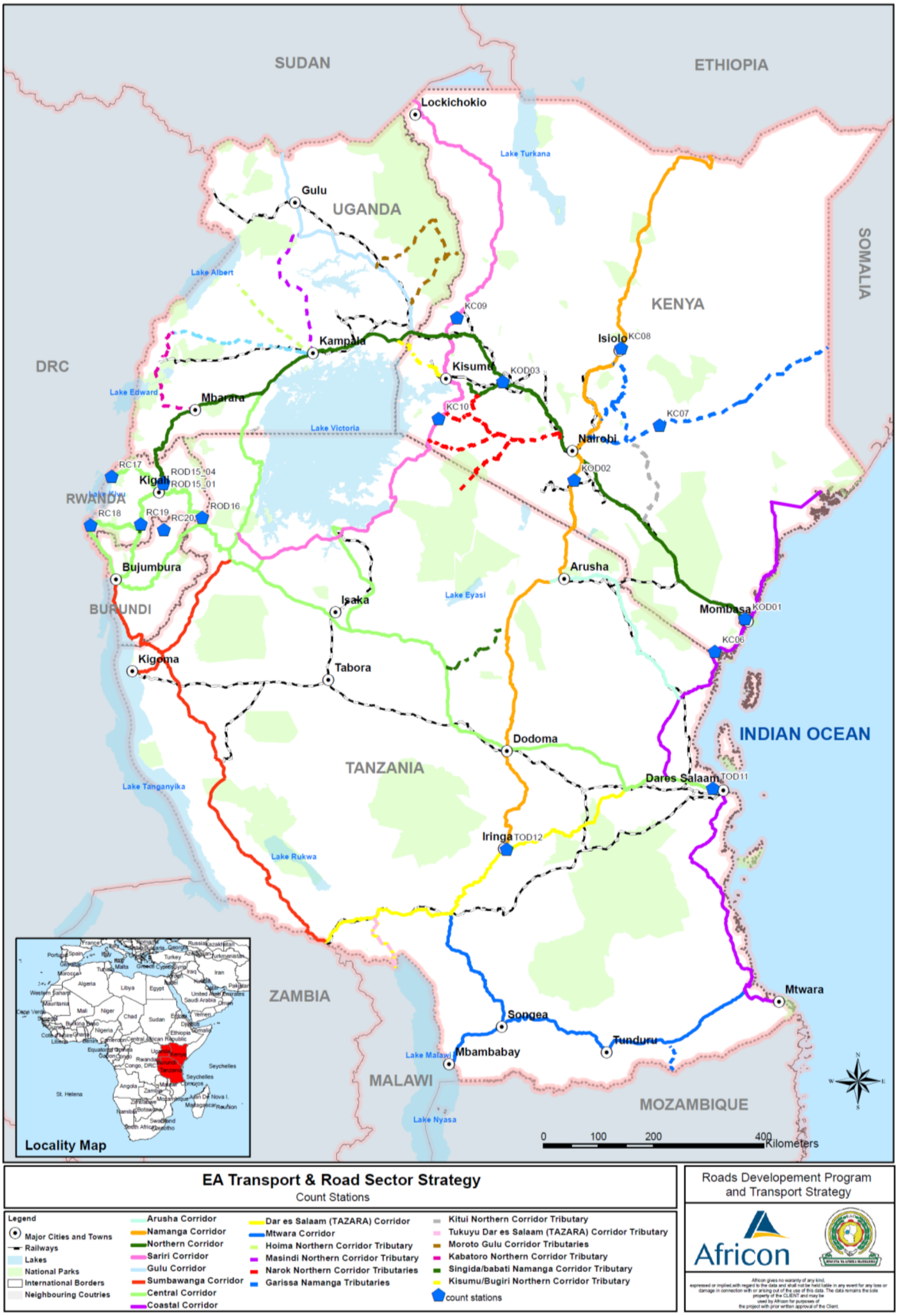
4.3.2.3 Survey Execution Dates

The traffic counts and OD surveys were executed on normal working days which imply either a Tuesday or Thursday in any given week where no public holidays or school holidays occurred. In Table 4-3 the survey dates are shown, some of the counting stations close to the major towns along the corridors were surveyed for three days in consecutive weeks. The traffic counts were done for a 12-hour period starting at 6 am and ending 6 pm. 12-hour counts were considered sufficient given that limited travelling occurred after sunset in the study area and as such the 12-hour counts are a close approximation of the 24-hour traffic movement in the region. The 30th highest hourly volume was calculated by applying a k-factor to the ADT data (24-hour traffic volume) obtained during the traffic surveys.

4.3.2.4 Data Processing and Validation Process

The process to capture the data surveyed during the traffic counts and OD surveys is indicated in Figure 4-7 below.

Two databases were developed in MS Access to capture the information from survey forms for both the traffic counts and the OD surveys. Figure 4-8 shows a snapshot of the capture tool developed in MS Access for the capturing of the OD information. The database design for both the databases was based on the survey forms. The data records captured and the outcome of the data validation process are detailed in Figure 4-8 and Table 4-4 below.



Map 4-1: Traffic Counts and OD Survey Locations

Table 4-3: Traffic Counts and OD Survey Dates, Durations, and Sample Size

Country	Count Station ID	Survey Type	Dates Counted	Start Time (Start of the hour)	End Time (Start of the hour)	Maximum Number of vehicles
Kenya	KC 06	Traffic Count	2009/12/02	06:00:00 AM	05:00:00 PM	990
Kenya	KC 07	Traffic Count	2009/12/02	06:00:00 AM	05:00:00 PM	1 070
Kenya	KC 08	Traffic Count	2009/12/02	06:00:00 AM	05:00:00 PM	823
Kenya	KC 09	Traffic Count	2009/12/02	06:00:00 AM	05:00:00 PM	929
Kenya	KC 10	Traffic Count	2009/12/02	06:00:00 AM	05:00:00 PM	1 338
Kenya	KOD 01	Traffic Count & OD Survey	2009/11/242009/11/252009/11/262009/12/012009/12/022009/12/03	06:00:00 AM	05:00:00 PM	7 732
Kenya	KOD 02	Traffic Count & OD Survey	2009/11/24 2009/11/252009/11/26	06:00:00 AM	05:00:00 PM	1 832
Kenya	KOD 03	Traffic Count & OD Survey	2009/11/24 2009/11/252009/11/26	06:00:00 AM	05:00:00 PM	10 613
Rwanda	RC 17	Traffic Count	2009/12/15 2009/12/162009/12/17	06:00:00 AM	06:00:00 PM	579
Rwanda	RC 18	Traffic Count	2009/12/15	06:00:00 AM	06:00:00 PM	166
Rwanda	RC 19	Traffic Count	2009/12/17	06:00:00 AM	06:00:00 PM	75
Rwanda	RC 20	Traffic Count	2009/12/17	06:00:00 AM	06:00:00 PM	59
Rwanda	ROD 15_1	Traffic Count & OD Survey	2009/12/152009/12/162009/12/17	06:00:00 AM	06:00:00 PM	499
Rwanda	ROD 15_2	Traffic Count & OD Survey	2009/12/152009/12/17	06:00:00 AM	05:00:00 PM	296
Rwanda	ROD 15_3	Traffic Count & OD Survey	2009/12/15 2009/12/162009/12/17	06:00:00 AM	05:00:00 PM	171
Rwanda	ROD 15_4	Traffic Count & OD Survey	2009/12/15	06:00:00 AM	05:00:00 PM	208
Rwanda	ROD 16	Traffic Count	2009/12/15 2009/12/162009/12/17	06:00:00 AM	06:00:00 PM	155
Tanzania	TOD 11	Traffic Count & OD Survey	2009/12/01 2009/12/022009/12/03	06:00:00 AM	05:00:00 PM	7 574
Tanzania	TOD 12	Traffic Count & OD Survey	2009/12/02	06:00:00 AM	06:00:00 PM	1 101

Source: Dates and Times of Traffic Count and Origin-Destination Surveys Completed by Africon

Figure 4-7: Data Processing and Analysis Process

Survey Forms from Counting Teams

- Receive Survey Forms from field
- Scan forms for back-up purpose
- Validate forms for completeness
- Determine total number of survey forms per station and records/entries.

Database Design

- Set-up Database according to survey forms
- Develop data capture module in MS Access

Data Capture

- Capture data with capture Module

Data Integrity Analysis

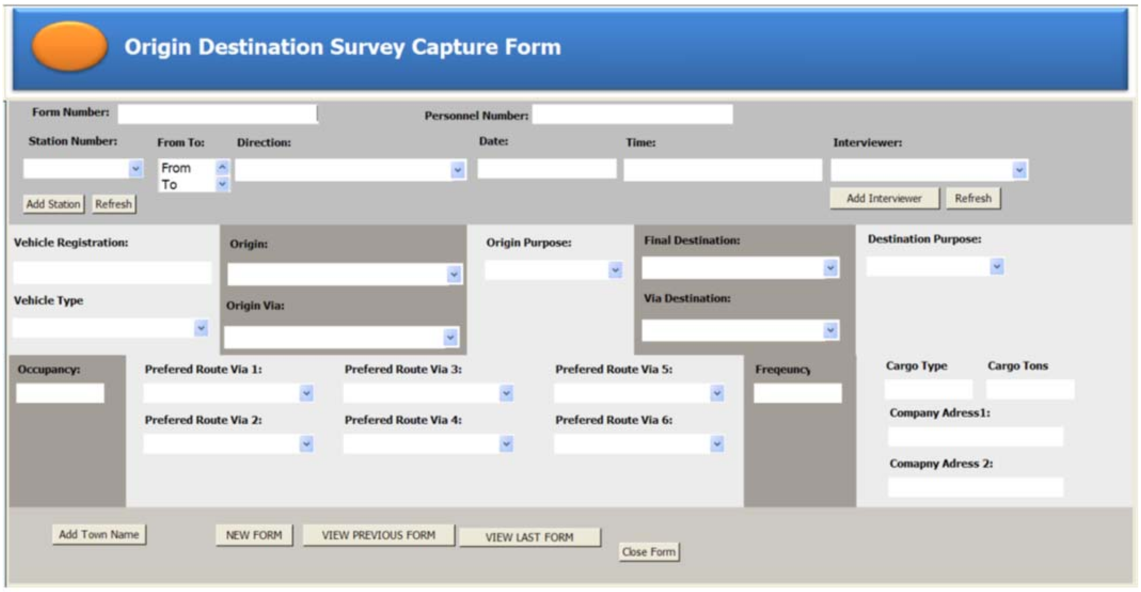
- Compare data captured to surveyed forms received for correctness/completeness,
- Correct if required
- Compare number of records captured to estimated number of records per survey form.

Data Analysis

- Traffic Counts
  - Determine the required output for FONA, Visum and HDM.
- OD Surveys
  - Determine the required output for FONA, Visum and HDM.

Reports

- Traffic Counts
  - Set-up report to present outcome of Analysis.
- OD Surveys
  - Set-up report to present outcome of Analysis.



Source: Developed by Africon, 2010

Figure 4-8: Origin Destination Capture Module (MS Access)

Table 4-4: Data Integrity Analysis

Data Survey	Survey Records	Number of Records after Data Integrity Analyses
Counts	3 473	3 473
OD Surveys	28 420	26 276

Source: Africon, 2010

Several of the Origin-Destination survey forms were not completed correctly by the enumerators, and were therefore discarded from the data capturing process. Some of the reasons for the discarding of records were:

- Unknown/incomplete/unmatched town names
- Origin-Destination not indicated
- Incomplete forms.

After the validation process the data was summarised and calculations done to obtain the parameters required in order to validate the secondary data sets.

4.3.2.5 Data Analysis

The parameters required from the surveys based on the model input requirements were as follows:

- Percentage vehicles in traffic stream
- ADT (from 12-hour traffic counts)
- k-factor to apply to ADT to calculate 30th highest design hour volume

In Table 4-5 the detail pertaining to the percentage vehicle class is summarised.

Table 4-5: Typical Day Classified Traffic Counts Data

Count Station ID	Date	Light vehicles	Heavy vehicles	Public Transport Vehicles	Total	% Heavy Vehicles	% Public Transport
KC 06	2009/12/02	252	23	440	990	2%	44%
KC 07	2009/12/02	472	55	248	1067	5%	23%
KC 08	2009/12/02	477	26	136	822	3%	17%
KC 09	2009/12/02	411	31	412	921	3%	45%
KC 10	2009/12/02	733	94	653	1999	5%	33%
KOD 01	2009/12/02	4 166	4 476	2 144	11 376	39%	19%
KOD 02	2009/11/25	1 380	466	713	2 726	17%	26%
KOD 03	2009/11/25	8 956	1 647	5 302	16 038	10%	33%
RC 17	2009/12/15	545	18	15	579	3%	3%
RC 18	2009/12/15	133	0	33	166	0%	20%
RC 19	2009/12/17	33	10	23	66	15%	35%
RC 20	2009/12/17	32	14	11	59	24%	19%
ROD 15_1	2009/12/16	243	117	101	499	23%	20%
ROD 15_2	2009/12/15	124	27	71	296	9%	24%
ROD 15_3	2009/12/15	64	8	42	171	5%	25%
ROD 15_4	2009/12/15	84	12	62	208	6%	30%
ROD 16	2009/12/16	31	26	24	88	30%	27%
TOD 11	2009/12/02	3 831	863	1 857	6 947	12%	27%
TOD 12	2009/12/02	437	375	260	1 098	34%	24%

Source: EAC Classified Traffic Count Data, Africon

The percentage heavy vehicle varies between 20% and 45%. Compared to the secondary data, this appears to be a low percentage of heavy vehicles. Based on the secondary data and visual observations made, the decision was made to use the percentage heavy vehicles obtained in the secondary data set in the models.

4.3.2.6 Deriving ADT from 12-hour Traffic Counts

The traffic counts were undertaken for a 12-hour period. The Average Daily Traffic (ADT) can be derived from the 12-hour counts by applying the formula below:

$$ADT = Peak\ Hour\ Volume/k$$

The k-factor is representative of the peak-to-daily volume ratio used to convert peak hour volumes to daily volumes. The k-factor varies between 8% and 12% in urban areas as well as between 12% and 18% in rural areas. The k-factor was calculated from the 12-hour counts by applying the following formula:

$$k = \frac{Maximum\ Daily\ Volume\ in\ Survey\ Period}{12 - Hour\ Average\ Daily\ Volume\ of\ surveys} \times \text{Average Peak to Daily Ratio}$$

Table 4-6 shows typical values obtained during traffic counts.

The above calculation method was applied to the primary data set. In the table below the k-factor per count station and day is shown. Count stations counted for less than 3 days were excluded for the purposes of the k-factor calculation as stations counted for less than 3 days can distort the calculation.

Table 4-6: Calculated k-factor from 12-Hour Traffic Counts (2009)

Count Station Number	Date	Highest Hourly Volume	12 hour Traffic Volume	K factor per station
KOD 01	2009/11/24	527	4 115	0.13
KOD 01	2009/11/25	509	4 319	0.12
KOD 01	2009/11/26	584	4 583	0.13
KOD 02	2009/11/24	169	1 672	0.10
KOD 02	2009/11/25	229	1 832	0.13
KOD 02	2009/11/26	168	1 747	0.10
KOD 03	2009/11/24	1 005	10 313	0.10
KOD 03	2009/11/25	1 021	10 613	0.10
KOD 03	2009/11/26	632	6 549	0.10
ROD 15	2009/12/16	15	134	0.11
ROD 15	2009/12/17	19	139	0.14
ROD 16	2009/12/15	19	155	0.12
ROD 16	2009/12/16	12	88	0.14
ROD 16	2009/12/17	13	102	0.13
TOD 11	2009/12/01	811	7 574	0.11
TOD 11	2009/12/02	762	6 948	0.11
TOD 11	2009/12/03	824	7 363	0.11

Source: Africon, 2010

The k-factors most common in the above data are 11% and 13%. Given that the majority of the network runs through rural areas the k-factor selected was 13%.

4.3.2.7 Calculation of 30th Highest (Design) Hour Volumes

The following formula is used to calculate the 30th highest hour traffic volume:

$$\text{30th Hour Design Volume} = \text{AADT x k}$$

No AADT's were available in the secondary data provided by the Member States, therefore it was deemed practical to use the calculated k-factor and apply it to the ADT received from the Member States to calculate the 30th highest (design) hour volume. This method is in effect mathematically skewed but due to the limited traffic counting programs in the Member States it was the only option available to the traffic analysis team.

The formula used to calculate the design hour traffic volumes was as follows:

$$\text{Design Hour Volume} = \text{ADT x k(calcuated from 12 hour counts)}$$

4.3.2.8 Variation in Primary and Secondary Data

The secondary data was compared to the primary data set. The comparison between the primary data calculated ADT and the secondary projected ADT data is presented in Table 4-7. The correlation between the data sets is in two instances significantly different and cannot be used for comparison purposes. In the other three counts station comparisons the ADT correlate within 15% variation.

Table 4-7: Secondary Data Compared to Primary Data

Location	2009 ADT Primary Data Set	2010 ADT Secondary Data Set	Difference between ADTs (Percentage)	
Mariakani	4 334	3 692	642	(15%)
Kajiado	2 037	1 136	901	(44%)
Nairobi (Rironi)	9 109	14 864	-5 755	(-63%)

Location	2009 ADT Primary Data Set	2010 ADT Secondary Data Set	Difference between ADTs (Percentage)	
Kibaha	6 699	6 950	-251	(-4%)
Iringa	1 101	1 103	-2	(-0.2%)

Source: Africon, 2010

4.3.2.9 Origin-Destination Matrices

The OD information collected during the primary surveys was associated with the local town names. These locations were plotted on a GIS platform and the positions were linked to the VISUM model zones. Each town was linked or categorised according to a VISUM zone number.

Limited OD surveys were conducted at each counting station with the sample size ranging between 10% and 30% of the total daily traffic volume. Owing to this low sample size a weighting factor was required to estimate the vehicles for each OD pair captured in the OD survey. The OD weight factor was calculated as follows:

- Calculate the number of vehicles in each vehicle class captured in the OD survey location
- Determine the number of vehicles counted at the specific counting station per vehicle class
- Compare the number of vehicles in each class and calculate the proportions
- Determine a weighting factor to be applied to the OD survey of vehicle sample to ensure that the same number of vehicles counted during the traffic count surveys are represented in the OD matrix at the specific OD survey location.

OD matrices were prepared in Excel format for the purpose of calibration of the VISUM model and were classified according to light, heavy and public transport matrices.

4.3.2.10 Other Source Data Validation

Traffic surveys forming part of the East Africa Corridor Diagnostic Study for the Northern and Central Corridor done by Nathan Associates was used as an additional data source to validate the ADT provided in the secondary data set. The said surveys were done for a 24-hour period at nine locations in Tanzania. Only five of these locations were along the primary EAC road network.

The comparison was a manual process, to determine the correlation between the data sets. The correlation is shown in Table 4-8.

Table 4-8: EAC Northern and Central Corridor Study Traffic Data Comparison

Location		Nathan 24-hour Volume	Secondary Data set 12 hour Volume	Number of trips both direction
From Town	To Town			
Dodoma	Morogoro	963	768	-195
Nzega	Singida	345	342	-3
Makunyuni	Arusha	603	591	-12
Nzega	Isaka	372	236	-136

Source: Africon, 2010

4.4 Phase 4: Data Assumptions

Analysis of the available data sources indicated that limited traffic volume information was available in Rwanda and Burundi and road geometry information required by the various models was not readily available from the Member States. A number of assumptions were made in order to estimate the vehicle volumes where no information existed.

ADT and Design Hour Traffic:

The following approach was followed in assuming ADT and Design hour traffic volumes where no primary or secondary data existed. Similarly, other external data sources were interrogated in order to augment road geometry information:

- Determine car ownership per 1 000 population of the nearest town where traffic data was limited
- Determine population of nearest town
- Calculated number of vehicles based on cars per 1 000 population
- Assume 70% travel during peak hour of the day
- Divide the number of vehicles between main access roads to and from CBD or major highways leading to and from town
- It was assumed that the traffic volume will decrease based on the increase of the distance from the CBD along the main arterials. A percentage was assumed based on the distance between neighbouring towns. If the towns were close together the percentage decrease per kilometre increase was less significant than neighbouring town a substantial distance (>100km) apart.

Percentage Heavy Vehicles:

The following approach was followed in assuming percentage heavy vehicle volumes where no primary or secondary data existed. Similarly, other external data sources were interrogated in order to augment road geometry information:

- Primary corridor count/survey locations of heavy vehicle volumes and percentages were used as a starting point
- The percentage was extrapolated to the adjacent corridor links.
- If the link characteristics changed from corridor to corridor feeder, the percentage was lowered to 50% heavy vehicles from 75% heavy vehicles and to 20% heavy vehicles from 50%.

Urban/Rural and Terrain:

The following approach was followed in assuming ADT and Design hour traffic volumes where no primary or secondary data existed. Similarly, other external data sources were interrogated in order to augment road geometry information:

- Google Earth was used to determine the following parameters:
    - Terrain – Each road link required a rolling/mountainous or level terrain classification. The terrain option of Google was used to initially populate the terrain type parameter and the terrain was validated in an internal EAC project workshop involving study team members with local knowledge of the topography and terrain of the East Africa region.
    - Urban or rural character of the areas surrounding the primary EAC road network
    - Number of accesses per km of the primary road network per link.

Other Criteria Required

The road infrastructure and operational assumptions relating to the remaining FONA Capacity Assessment model parameters are shown in Table 4-9.

Table 4-9: Road Infrastructure Assumptions

FONA Parameter Required Description	Parameter Assumption
Number of lanes	1 lane per direction (for the majority of the network validated using Google earth to determine where more than one lane per direction exists)
Dual carriageway or single carriageway	Used Google earth to determine road geometry

FONA Parameter Required Description	Parameter Assumption
Lane width	3.4m where no other data was available
Lateral clearance distance left hand side	Assumed 1.8m clearance
Lateral clearance distance right hand side	Assumed 1.8m clearance
30th Highest Design Hour	Applied k-factor of 13% to calculate the 30th highest design hour from ADT.
Percentage heavy vehicles in traffic stream	Primary and Secondary data
Percentage recreational vehicles in traffic stream	Assumed: - Urban classified links = 0.5% - Rural classified links = 5%
Terrain Type	Google Earth survey[3] of terrain classified according to level, rolling or mountainous terrain
Driver population indicator	Assumed: - Urban traffic = 1.0 - Rural traffic = 0.85
Number of accesses per kilometre of link - Definition: nr of times the secondary road intersects with primary roads	Google Earth survey
% of link with no passing opportunities	Assumption based on terrain type: - Level = 20%, - Rolling = 50%, - Mountainous = 80%
Base free flow speed	Assumption based on terrain type:: - Level = 100km/h, - Rolling = 90km/h, - Mountainous = 80km/h
Peak hour factor	Assumed: - Urban = 0.92, - Rural = 0.88
Urban or Rural road link classification	Google Earth Survey identifying large settlements and cities

Source: Africon, 2010

4.5 Phase 5: Complete Data Set

The above-motioned process was followed each time the secondary data set was updated to form one complete set of information. The data set was hosted in a GIS platform where all the model parameters and the road geometry parameters could be linked to the physical location of the road segment. Other information pertaining to the corridor names, and model link preference numbers were also hosted in this file, therefore allowing standardisation, interrelationship and interface of data between the three model platforms (ie. FONA, HDM-4, VISUM).

[3] Google Earth 2010 was used to fly along the primary roads in 3D view and determine the terrain and other attributes.

4.6 Phase 6: Model Parameter Input

The GIS shape file was formatted as such that the transfer of the model parameter information from the shape file to the model in question was a seamless process. It is important to note that the link between the GIS and the models was not lost during the running of the models and the output of the models was transferred back into the GIS file and MS Access database.

5. ROAD CAPACITY

5.1 FONA Model

FONA is essentially a modelling tool developed by Africon based on the Highway Capacity Manual 2000 (HCM) (Transportation Research Board, 2000) methodology calculations with the purpose of providing a first order ‘snapshot’ analysis of the existing operating conditions of a country’s major roadways using the existing road infrastructure and traffic volumes as base input.

5.1.1 Analysis Approach

The FONA analysis approach is based on the HCM two-lane and multi-lane freeway operational calculations. The definition of a **two-lane freeway** is a single-roadway providing for two-way traffic. Traffic travelling in a particular direction, wishing to overtake slower moving vehicles, therefore have to make use of overtaking opportunities allowed by the absence of barrier (no-overtaking) lines (informed by the road’s horizontal and vertical alignment) and gaps in the stream of oncoming (opposing) traffic. Generally in the EAC roads environment, rural roads tend to fall under this description.

Multi-lane freeways, on the other hand, generally tend to occur in the proximity of urban / metropolitan areas. A multi-lane freeway provides for multiple lanes of travel per direction. This type of roadways generally is divided by a median barrier in the middle of the road although this is not a requirement for this particular classification. The major difference however lies in the traffic’s ability to overtake slower moving vehicles without having to contend with oncoming traffic flowing in the opposing direction.

5.1.2 Choice of Level of Service

The key performance indicator that is used to evaluate the status of vehicular operations on a roadway is expressed in terms of Level of Service (LOS). LOS is indicated by using the letters of the alphabet (‘A’ through to ‘F’), ‘A’ representing the best operating conditions and ‘F’ the worst. When new road infrastructure is designed, most public sector entities tend to require a design LOS of at least ‘C’ in the design year – in other words, if a facility is designed to last for a period of seven years, in year seven the facility should preferably still operate at a LOS of ‘C’. The reality within most countries, however, is at a level that is usually exceedingly lower than this ideal situation, especially in and around urban environments.

The LOS for different kinds of analysis is determined using different approaches as recommend by the HCM. For two-lane and multi-lane freeways the approaches to measure LOS also differs but provides the practitioner with results that are comparable on from one type of facility to the next.

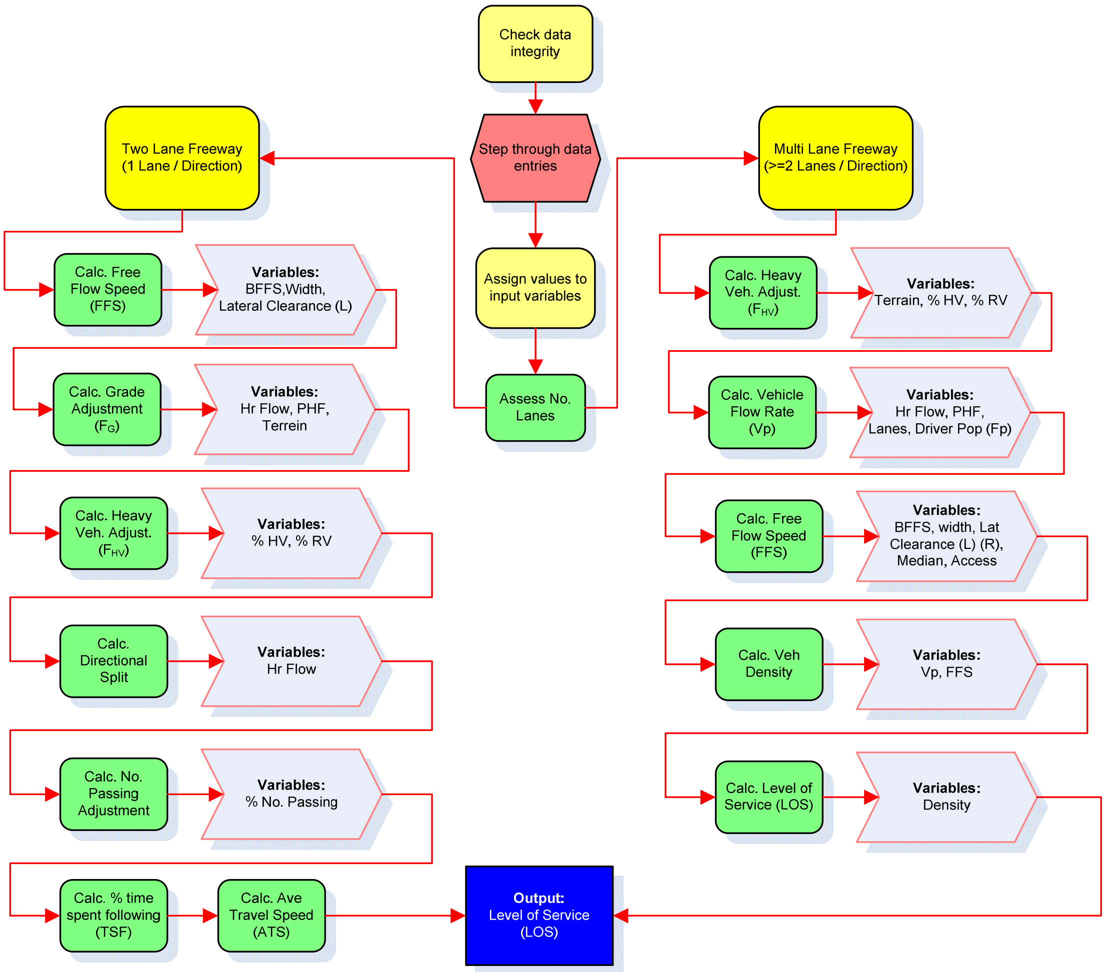
- Two-lane facilities

  LOS is determined in terms of both *percent time-spent-following* and *average travel speed*. These two factors provide a representative measure of the efficiency of mobility. The worst of the two measures is taken as representative of the facility.

- Multi-lane facilities

  LOS is determined as a relationship between the *average passenger-car speed* and the *traffic density*. It provides an indication of the freedom of a vehicle to manoeuvre within the traffic stream as well as the vehicle’s proximity to other vehicles.

The process flow of the FONA model HCM calculation is shown in Figure 5-1.



Source: Africon, 2010

Figure 5-1: HCM Two-Lane and Multi-Lane Freeway Analysis Process Flow

For each homogenous section of road, the following information was calculated:

- The LOS in the base year (selected base year was 2010);
- The LOS in the target year (selected target year is 2020);
- The estimated vehicular flow in the target year at an assumed traffic growth rate;
- The estimated vehicular flow at which a threshold/target LOS of 'D' will be reached for each roadway segment analyzed;
- The year during which the threshold/target LOS will be reached assuming no upgrades and an assumed traffic growth rate;
- The number of additional lanes required per direction in order to achieve/maintain the threshold/target LOS for each road segment analyzed;
- The LOS that will be achieved within the target year assuming that the additional required lanes are provided.

The benefit of following this methodology is that it aligns with international best-practice. The methodology allows for refinement of results on selected roadways by refining the accuracy of input data in order to achieve this and it provides a first-order estimate of the actual operating conditions on the EAC Major Corridors identified for the EAC Transport Strategy and Regional Roads Sector Development Program, thereby allowing quick insight into the scale of upgrading that would be required to maintain a nominal economic growth rate over time, assuming that for at least the next 10 years, the EAC will remain dependant on road-based transportation as a fundamental part of commuter, recreational and freight transportation.

5.1.3 Assumptions and Parameters

In order to fully understand the complexities of the HCM two-lane and multi-lane calculation methodologies for validation and calibration purposes a rigorous parameter sensitivity analysis was undertaken. Each of the model parameters was tested against a control data set by calculating results (i.e. LOS trigger volumes) for each of the parameter input values through their range of possible inputs. Table 5-1 shows the input parameters that were subjected to sensitivity analysis.

Each of the input parameters was tested, across their range of variability, against a network set at optimal performance parameters. The optimal network performance parameters are defined as follows:

- Lane width = 3.7m
- Lateral Clearance > 1.8m
- Traffic Flow (Analysis direction) = Linear increasing in 5 vehicle intervals
- Opposing flow = Linear increasing in 5 vehicle intervals
- Percentage heavy vehicles = 0%
- Percentage Recreational vehicles = 0%
- Peak Hour Factor (PHF) = 0.95
- Terrain type = Level terrain
- Driver population (fp) = 1 (Commuter / weekday traffic / familiar drivers)
- Level of access per kilometre (LOA/km) = 0 accesses per kilometre
- Base free-flow speed (BFFS) = 100km/h
- Percentage no-passing on link = 0% no passing

The results from the sensitivity analyses will be discussed in the subsequent sections of this report.

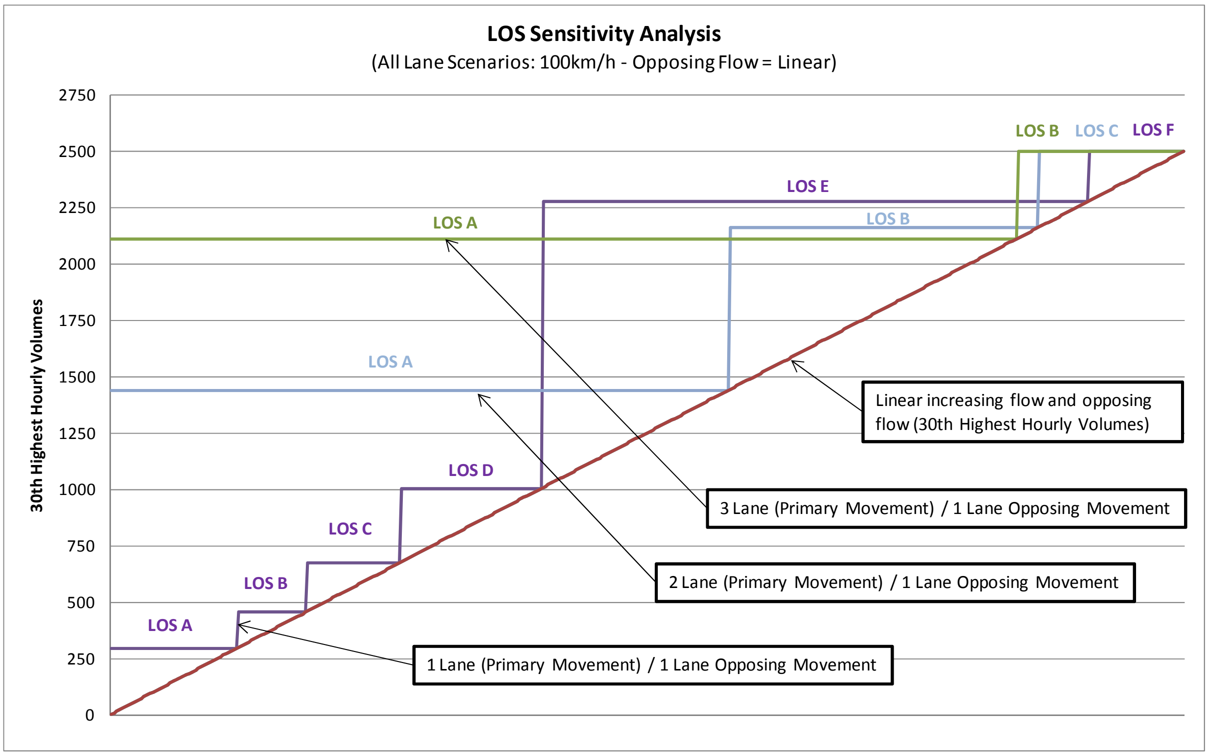
5.1.3.1 Number of Lanes

The HCM methodology shows that LOS trigger volumes are ***highly elastic (highly sensitive)*** in response to lane additions on the network. Although it was anticipated that LOS is highly responsive to lane additions, the degree of responsiveness was underestimated. Changing the analysis road network from 1 lane to 2 lanes in the primary direction of travel results in a significant network LOS improvement whereby all links fall within the LOS A, B and C categories. LOS D, E and F were completely removed by adding an additional lane. Adding a subsequent third lane to the analysis network results in all links either operating and LOS A or B (Refer to Figure 5-2).

Table 5-1: HCM Two-lane and Multi-lane Parameters subjected to Sensitivity Analysis

No.	Data Field	Description	Scenario Description	Range	Optimum
1	Lanes	Number of lanes (Base year scenario)	Scenarios ranging from 1 to 4 lanes (Interval = 1 lane).	1 to 4 lanes	3
2	Lane width	Lane width (m)	Scenarios ranging from 3.0m to 3.9m lane widths (Interval: 0.1m).	3.0m to 3.9m	3.7m
3	Verge_width_L	Lateral clearance distance to obstacle next to road	Scenarios ranging from 0m to 1.8m both sides (Interval: 0.2m)	0m to 1.8m	>1.8m
4	Verge_width_R	Lateral clearance distance to obstacle next to road	Scenarios ranging from 0m to 1.8m both sides (Interval: 0.2m)	0m to 1.8m	>1.8m
5	Opp. Flow	Opposing Flow (Same hour as 30th Highest Hourly Volume)	Scenarios ranging from 100 to 1000 opposing flow (Interval: 100 vehicles).	0 to 1000	0
6	%HV	% Heavy vehicles in traffic stream (Base year scenario)	Scenarios ranging from 0% HV to 60% HV (Interval: 5% HV).	0% to 100%	0%
7	%RV	% Recreational vehicles in traffic stream	Scenarios ranging from 0.5% (Urban) to 5% (Rural) (Interval = 0.5%)	0% to 50%	0%
8	PHF	Peak Hour Factor	Scenarios ranging from 0.80 to 0.98 PHF (Interval = 0.02) (Categorisation: Urban = 0.92 / Rural = 0.88)	0 to 1.0	1
9	Terrain	Terrain type (proxy for link gradient)	Scenarios ranging from 'Mountainous', 'Rolling' and 'Level'.	Level to Mountainous	Level
10	Driver_Pop (fp)	Driver Population Indicator	Scenarios ranging from 0.80 to 0.90 (Interval = 0.05) (Categorisation: Commuter Traffic (Urban - Weekday) = 1.0 / Rural Traffic = 0.85)	0.85 to 1.0	1
11	LOA/km	Number of accesses per kilometre of link	Scenarios ranging from 0 to 24 accesses per kilometre. (Interval = 2 accesses per kilometre)	0 to 24 Accesses	0
12	BFFS	Base Free Flow Speed	Scenarios ranging from 70km/h to 100 km/h (Interval = 5km/h).	>70km/h <100km/h	100km/h
13	%No_Pass.	% of link with no passing opportunities	Scenarios ranging from 0% to 90% no passing opportunity along each link (Interval = 10%).	0% to 90%	0%

Source: Africon, 2010



Notes on Scenario Statistics: 3 scenarios, 1500 links, Linear increasing traffic volumes, Interval: 1 lane added per scenario.

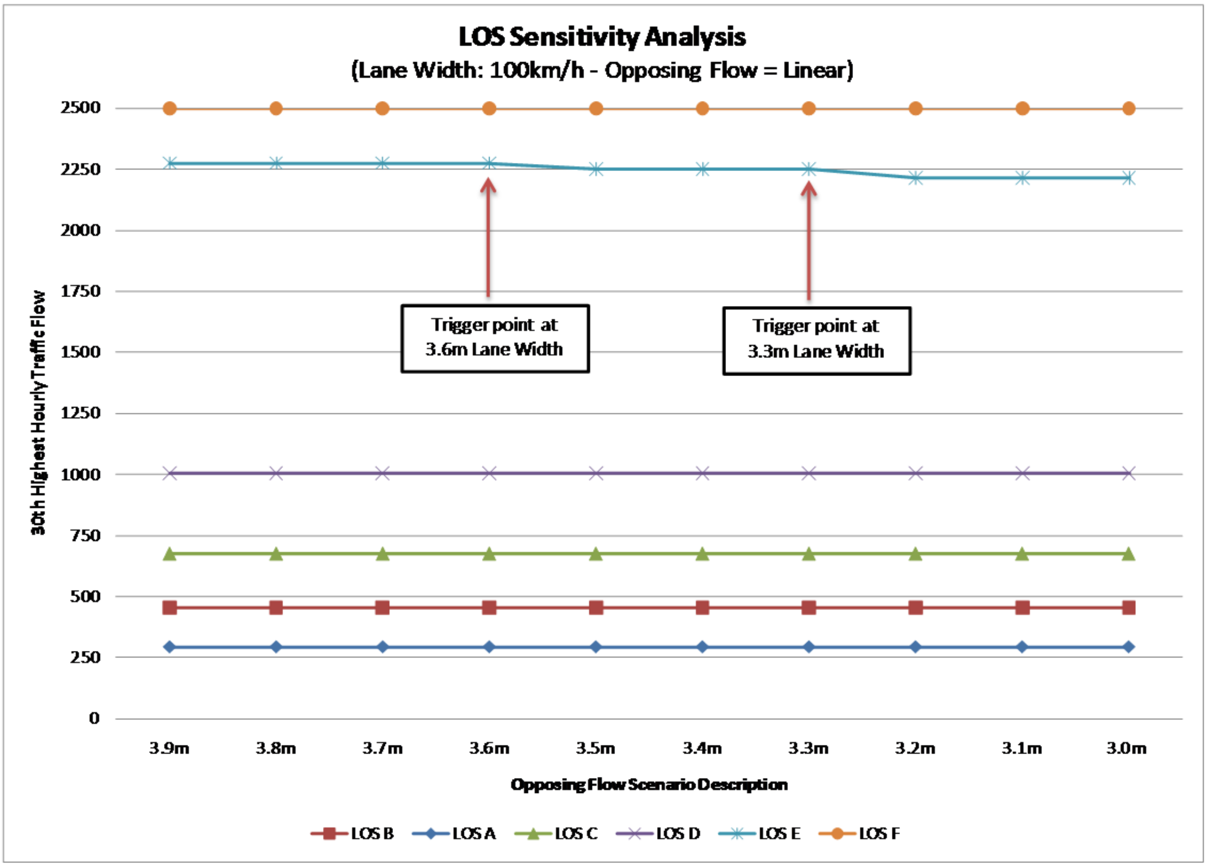
Source: Developed by Africon, 2010

Figure 5-2: Number of Lanes – LOS Sensitivity Analysis Results

5.1.3.2 Lane Width

The HCM methodology shows that LOS trigger volumes are ***relatively inelastic (insensitive)*** in response to lane width changes on the network (Refer to Figure 5-3). According to the sensitivity analysis, LOS trigger volumes only respond to lane width changes at 3.3m and 3.6m lane widths.

Therefore, only three levels of lane width options need to be accommodated in the HCM analysis methodology, namely <3.3m lanes, >=3.3m and <3.6m lanes and >=3.6 m lanes. All other lane widths present unitary elasticity in respect to LOS trigger volumes.



Notes on Scenario Statistics: 10 scenarios, 5000 links, Linear increasing traffic volumes, Interval: 0.1m lane width added per scenario.

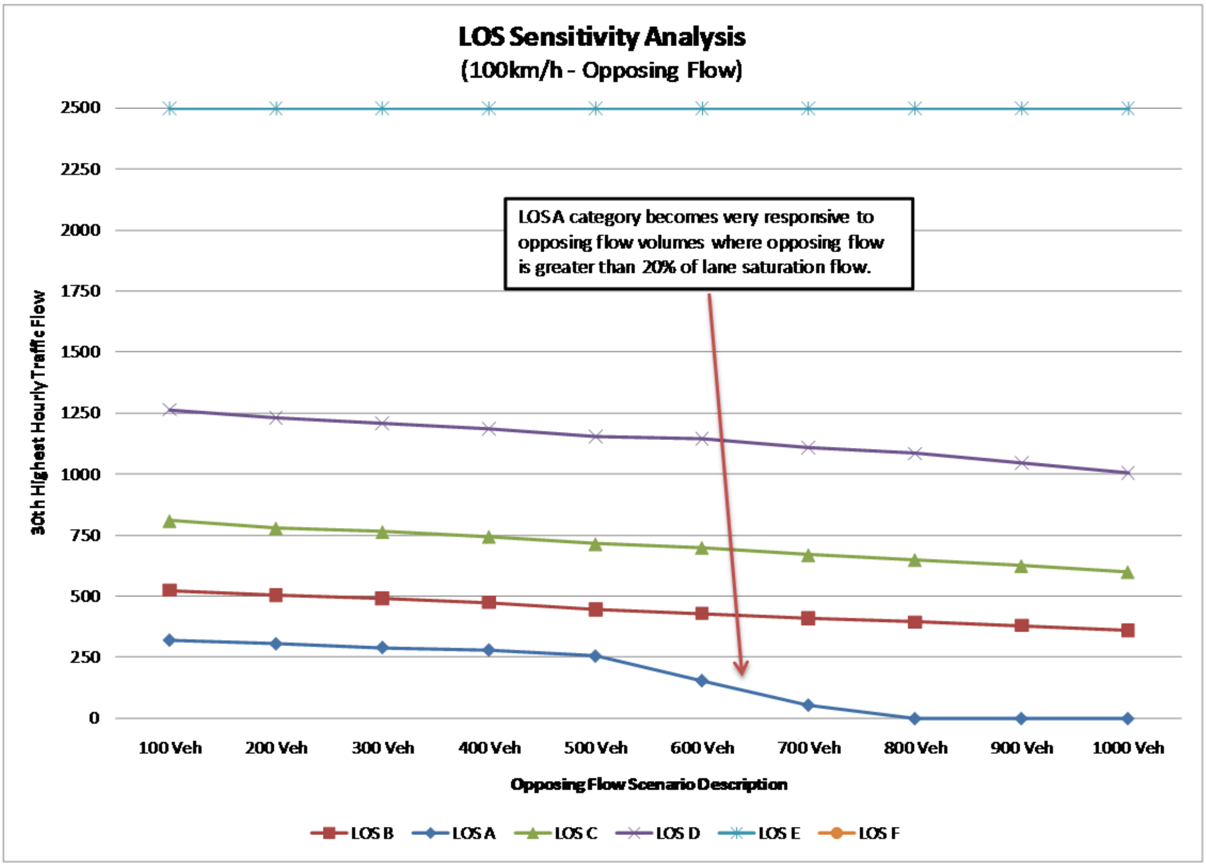
Source: Developed by Africon, 2010

Figure 5-3: Lane Width – LOS Sensitivity Analysis Results

5.1.3.3 Opposing Traffic Flow (Directional Split)

The HCM methodology shows that LOS trigger volumes are ***relatively elastic (moderate sensitivity)*** in response to opposing flow (directional split) changes on the network (Refer to Figure 5-4). LOS B, C, D and E categories show linear decreasing trend in response to increases in opposing flow increases. For these categories, for every additional 100 vehicles opposing flow the LOS trigger volume reduces by approximately 3% on average. LOS A also exhibits a linear decreasing trend until the opposing flow equals approximately 20% (500 vehicles) of the assumed lane saturation flow (2500 vehicles). At this point the LOS trigger volumes reduce dramatically at an average rate of 50%. At opposing flow volume of 800 vehicles (32% of lane saturation flow) LOS A category is eliminated from the operational conditions, irrespective of the primary analysis direction traffic volume.

The linear decreasing trend of the LOS category trigger volumes was an unexpected result from the sensitivity analysis. The expectation of the authors was that the LOS category trigger volumes would represent a characteristically negative exponential curve in response to increasing opposing flow volumes.



Notes on Scenario Statistics: 10 scenarios, 5000 links, Linear increasing traffic volumes, Interval: 100 opposing flow vehicles added per scenario.

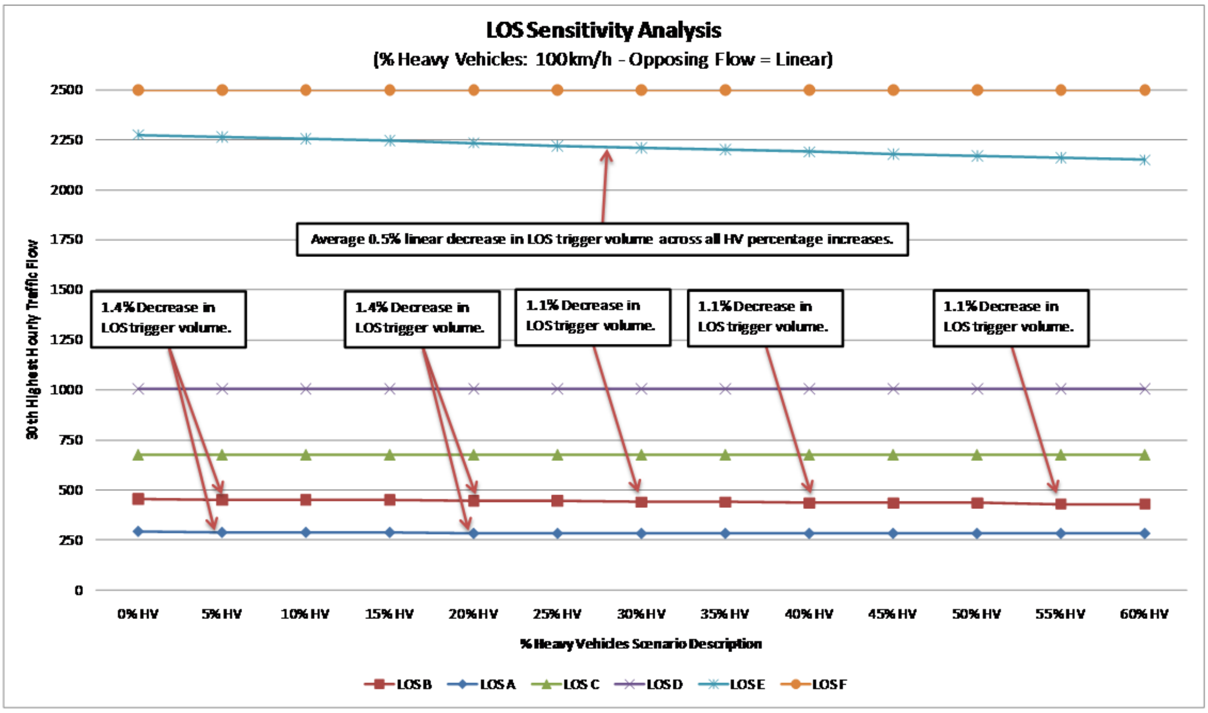
Source: Developed by Africon, 2010

Figure 5-4: Opposing Flow (Directional Split) – LOS Sensitivity Analysis Results

5.1.3.4 Percentage Heavy Vehicles

The HCM methodology shows that LOS trigger volumes are ***relatively inelastic (insensitive)*** in response to percentage heavy vehicles in the traffic stream on the network (Refer to Figure 5-5). According to the sensitivity analysis LOS E trigger volumes shows consistent linear sensitivity towards increases in percentage heavy vehicles in the traffic stream. On average, a 5% increase in heavy vehicle volumes results in a 0.5% reduction in trigger volume value for the LOS E category.

LOS A and B categories show sporadic elasticity to increases in percentage heavy vehicles in the traffic stream. On average, a 10% to 15% increase in percentage heavy vehicle volumes in the traffic stream results in an average 1.1% to 1.4% reduction in LOS A and LOS B trigger volume values.



Notes on Scenario Statistics: 13 scenarios, 6500 links, Linear increasing traffic volumes, Interval: 5% Heavy vehicles added per scenario.

Source: Developed by Africon, 2010

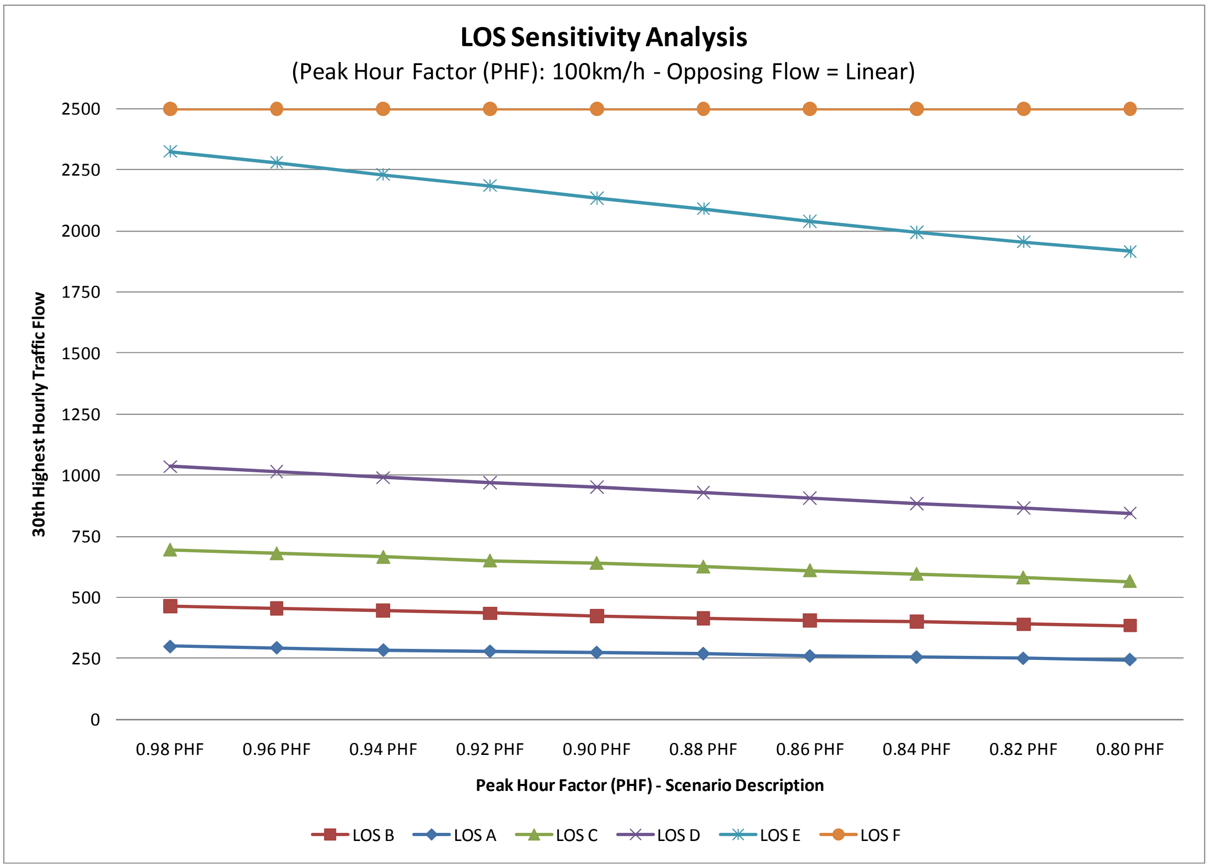
Figure 5-5: Percentage Heavy Vehicles – LOS Sensitivity Analysis Results

5.1.3.5 Peak Hour Factor (PHF)

PHF is defined as the relationship between the peak 15-minute flow rate and the full hourly volume. Generally speaking, peak-hour factors for freeways range between 0.80 and 0.95. Lower PHF values are more typical for rural freeways or off-peak conditions – indicative of a high volume of vehicles to be accommodated in one or two specific 15-minute periods within the peak hour. Higher PHF values are typical of urban and suburban peak-hour conditions – indicative of traffic volumes spread more evenly across all 15-minute periods within the peak hour.

The HCM methodology shows that LOS trigger volumes are ***relatively elastic (moderate sensitivity)*** in response to adjustments to the PHF of the traffic stream on the network (Refer to Figure 5-6). On average all LOS category trigger volumes reduce by approximately 2.2% for every PHF change of 0,02.

Higher PHF values (0.98) representing urban scenarios with more evenly spread volumes over the peak hour present higher tolerances across the LOS categories. Lower PHF values (0.80) representing rural scenarios with typically all hourly traffic volumes contained in one or two 15-minute periods within the peak hour have significantly lower LOS category trigger volume tolerances for LOS D and E.



Notes on Scenario Statistics: 10 scenarios, 5000 links, Linear increasing traffic volumes, Interval: 0.02 increase in PHF parameter per scenario.

Source: Developed by Africon, 2010

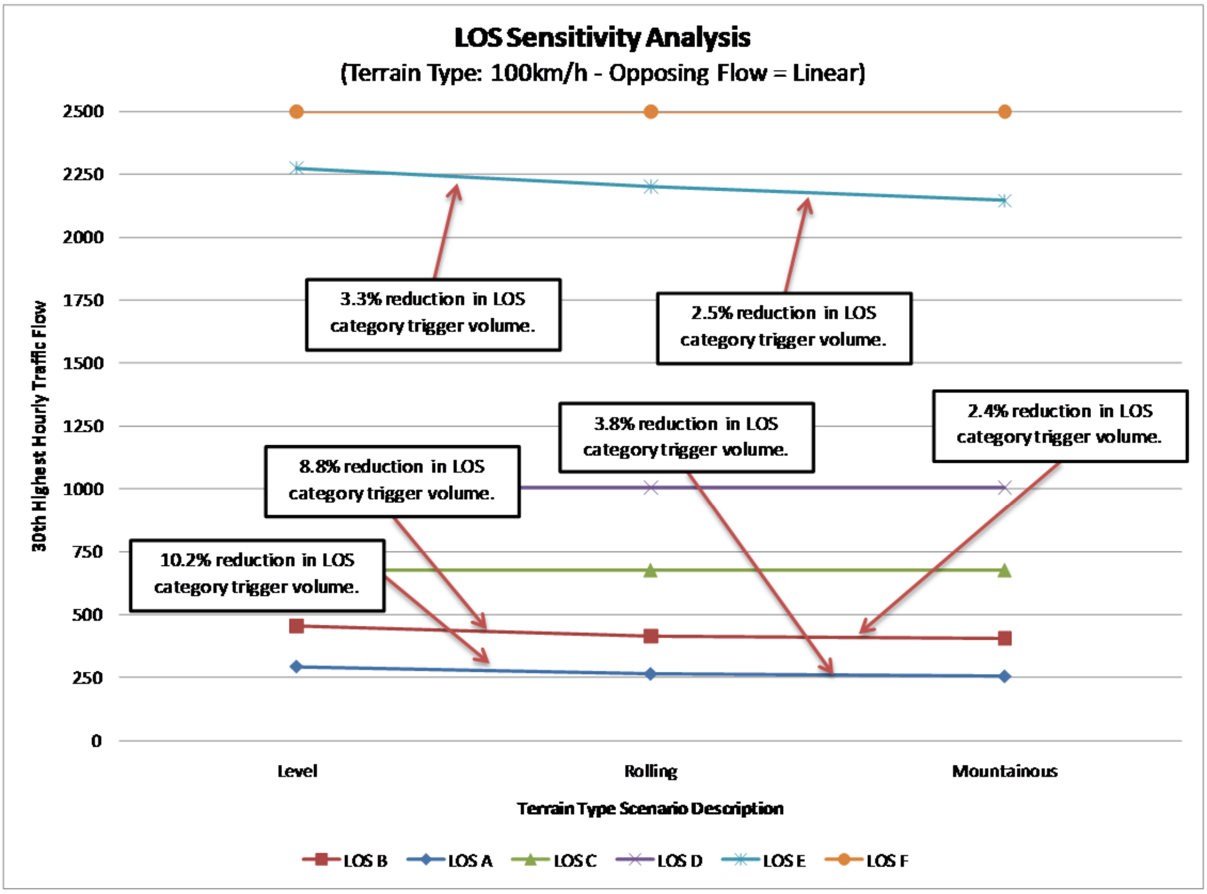
Figure 5-6: Peak Hour Factor – LOS Sensitivity Analysis Results

5.1.3.6 Terrain Type

The HCM methodology shows that LOS trigger volumes are ***relatively elastic (moderate sensitivity)*** in response to adjustments to terrain type associated with each network link (Refer to Figure 5-7). According to the sensitivity analysis, LOS category trigger volume values are more responsive to a terrain type change from category 'Level' to 'Rolling' than from category 'Rolling' to 'Mountainous'. In addition to this, only LOS categories A, B and E respond to changes in terrain type.

On average, terrain type change from category 'Level' to 'Rolling' results in a 10.2% reduction in LOS A category trigger volume value and only a 3.8% reduction in trigger volume value for a terrain type change from 'Rolling' to 'Mountainous'. LOS B category is less responsive than LOS A reflecting a 8.8% reduction in trigger volume value for a terrain type change from category 'Level' to 'Rolling' but only a 2.4% reduction in trigger volume value for a terrain type change from 'Rolling' to 'Mountainous'.

LOS E shows almost linear responsiveness to changes in terrain type with a 3.3% reduction in trigger volume value for terrain type change from category 'Level' to 'Rolling' and a 2.5% reduction in trigger volume value for a terrain type change from 'Rolling' to 'Mountainous'.



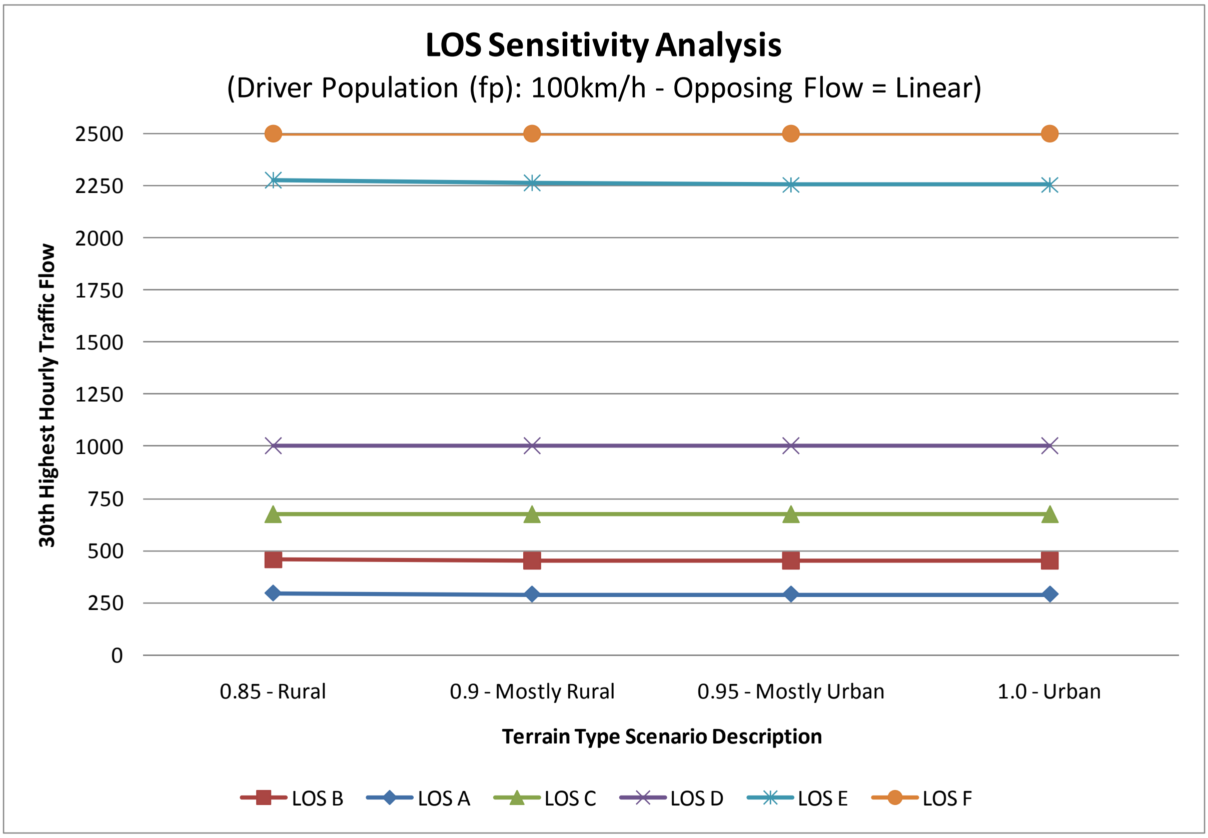
Notes on Scenario Statistics: 3 scenarios, 1500 links, Linear increasing traffic volumes, Interval: Different terrain type per scenario.

Source: Developed by Africon, 2010

Figure 5-7: Terrain Type – LOS Sensitivity Analysis Results

5.1.3.7 Driver Population

The HCM methodology shows that LOS trigger volumes are ***inelastic (insensitive)*** in response to adjustments to Driver Population (fp) characteristics of the traffic stream on each network link (Refer to Figure 5-8). Driver population characteristics typically vary from 0.85 (representing seasonal, non-local driver composition, non-commuter traffic) to 1.0 (representing commuter traffic with local drivers in the traffic stream).



Notes on Scenario Statistics: 4 scenarios, 2000 links, Linear increasing traffic volumes, Interval: 0.05 Driver population change per scenario.

Source: Developed by Africon, 2010

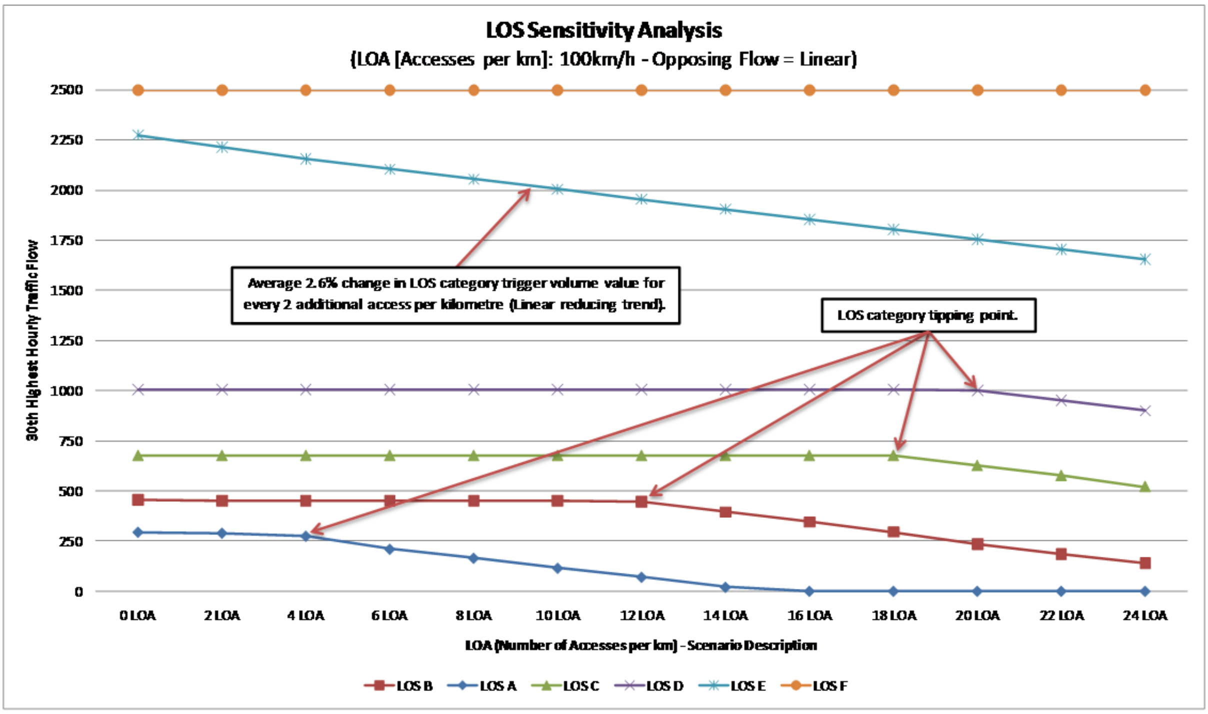
Figure 5-8: Driver Population (fp) – LOS Sensitivity Analysis Results

According to the sensitivity analysis, only LOS categories A, B and E respond to changes in driver population characteristics. LOS category A and B respond to a change in driver population from 0.85 to 0.90. In both cases the LOS category trigger volume values reduce by 1.7% and 1.1% respectively. This finding was in contradiction with the expectation of the authors. It is generally expected that a traffic stream consisting of commuter traffic primarily comprising local (familiar) drivers would exhibit higher tolerances with respect to LOS categories than for traffic streams comprising non-commuter non-local drivers.

LOS C and D categories are non-responsive to changes in driver population. LOS category E responds minimally to driver population changes. For every 0.05 change in driver population, the LOS E trigger volume value reduces by 0.5%.

5.1.3.8 Level of Access (Access per Kilometre)

The HCM methodology shows that LOS trigger volumes are ***highly elastic (highly sensitive)*** in response to the number of access per kilometre of analysis network (Refer to Figure 5-9). The sensitivity analysis shows that all LOS categories respond to the number of accesses per kilometre on the analysis network. LOS categories A, B, C and D show minimal reductions in LOS category trigger volume values up to a specific tipping point whereby each LOS category shows drastic reductions in trigger volume values. LOS category A trigger volumes reduce drastically from 4 accesses/km terminating at 16 accesses/km. LOS category B trigger volumes reduce drastically from 12 accesses/km and LOS C and D exhibits the same trend from 18 and 20 accesses/km respectively.



Notes on Scenario Statistics: 13 scenarios, 6500 links, Linear increasing traffic volumes, Interval: 2 accesses added per kilometre per scenario.

Source: Developed by Africon, 2010

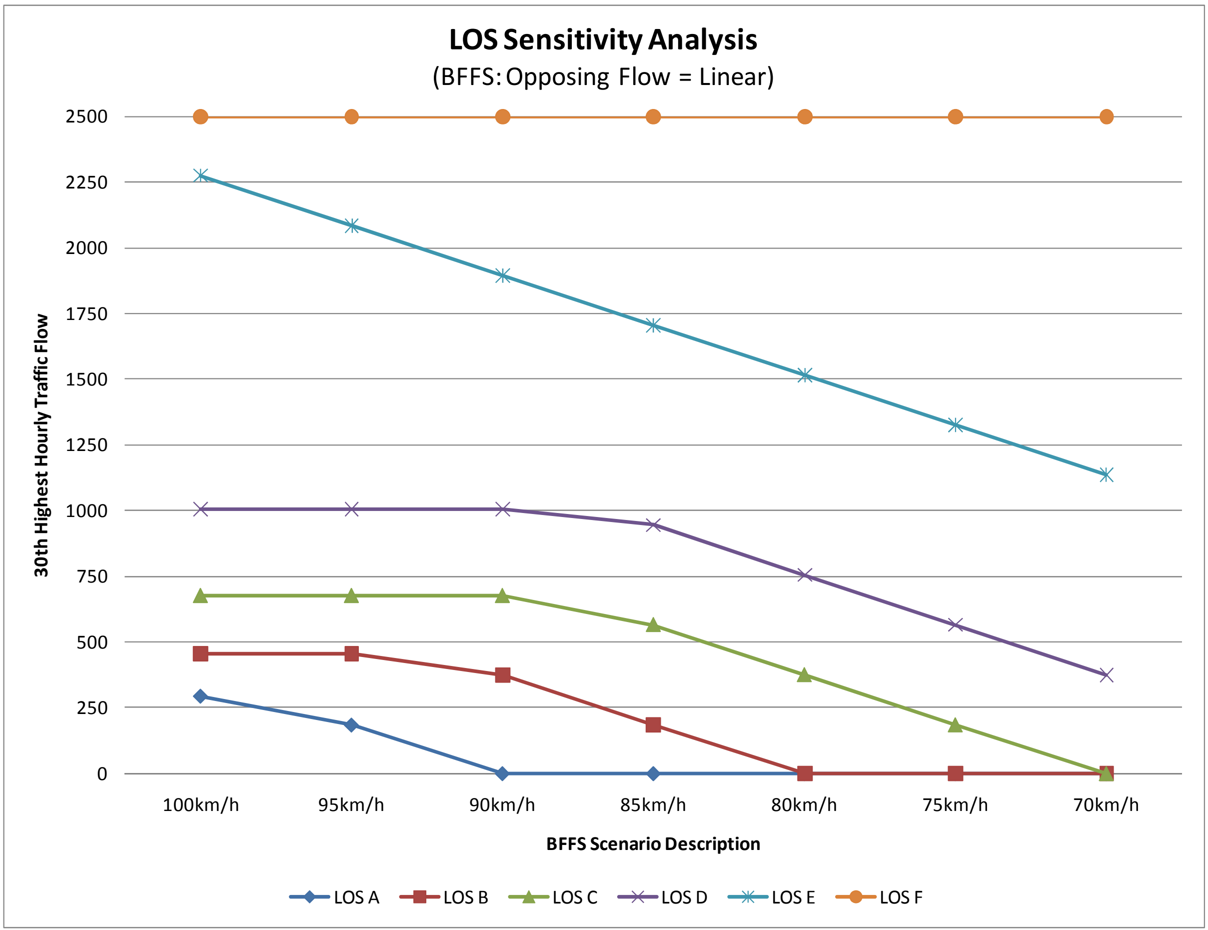
Figure 5-9: Level of Access – LOS Sensitivity Analysis Results

LOS category E exhibits a linear decreasing trend with regards to reducing trigger volume values at an average reduction of 2.6% of trigger volumes for every 2 accesses/km added to the network. No particular tipping point was observed for LOS E within the range of accesses per kilometre analysed.

5.1.3.9 Operating Speed

The HCM methodology shows that LOS trigger volumes are ***highly elastic (highly sensitive)*** in response to the operating speed of each link on the analysis network (Refer to Figure 5-10). The sensitivity analysis shows that all LOS categories respond to the link operating speed.

LOS category A responds immediately to a reduction in link operating speed from 100km/h to 90km/h. LOS category trigger volume values reduce at an average rate of 69% up to 90km/h at which point LOS A can no longer be attained by any link on the analysis network.



Notes on Scenario Statistics: 7 scenarios, 3500 links, Linear increasing traffic volumes, Interval: 5km/h operating speed increase per scenario.

Source: Developed by Africon, 2010

Figure 5-10: Operating Speed – LOS Sensitivity Analysis Results

LOS categories B, C and D show no reduction in LOS category trigger volume values up to a specific tipping point whereby each LOS category shows drastic reductions in trigger volume values. These tipping points are 90km/h and 95km/h respectively. LOS B category trigger volume values reduce at an average rate of 56% from 95km/h up to 80km/h at which point LOS B can no longer be attained by any link on the analysis network. LOS C category trigger volume values reduce at an average rate of 50% from 90km/h up to 70km/h at which point LOS C can no longer be attained by any link on the analysis network. LOS D category trigger volume values reduce at an average rate of 21% from 90km/h and exhibit a linear decreasing trend from 85km/h operating speed and lower.

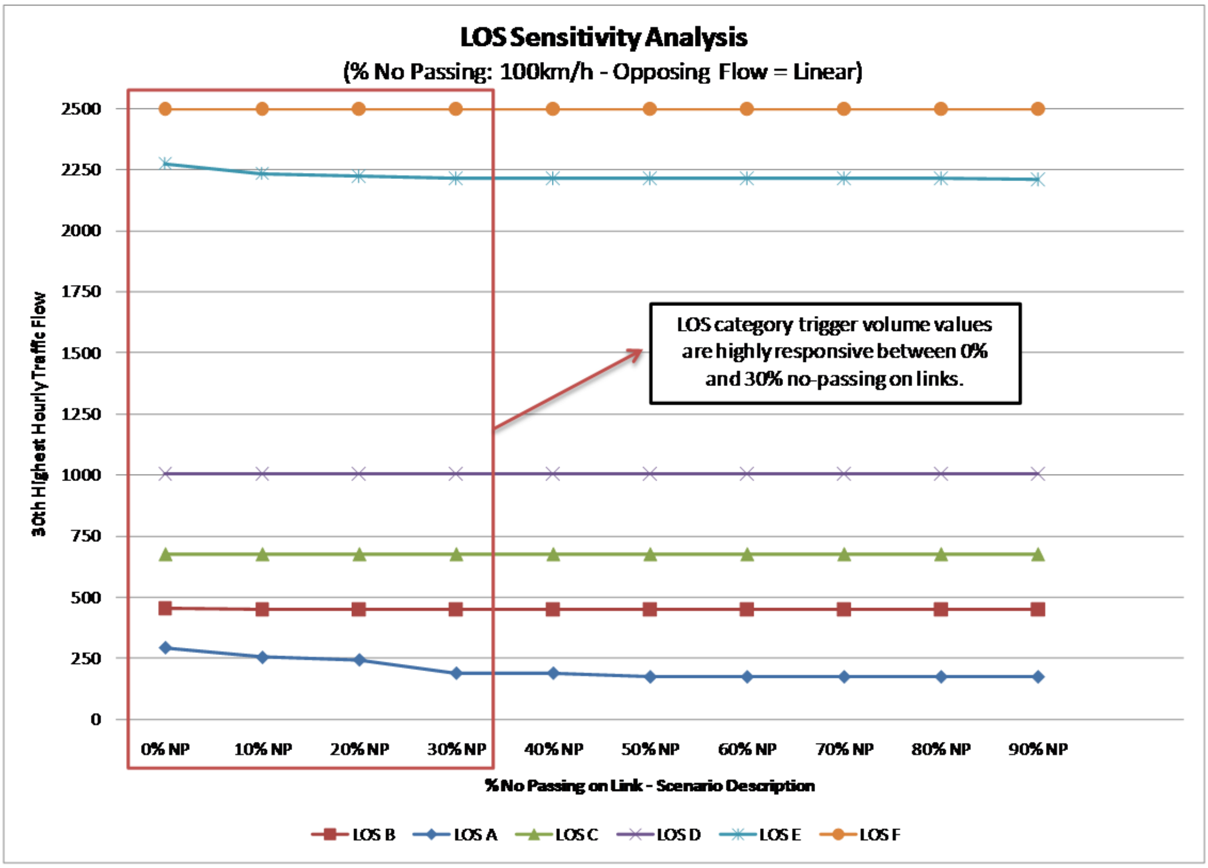
LOS category E exhibits an almost linear reducing trend with LOS category trigger volume values reducing at an average rate of 10% across all operating speed scenarios from 100km/h to 70km/h.

5.1.3.10 Percentage No-Passing on Each Link

The HCM methodology shows that LOS trigger volumes are ***relatively elastic (moderately sensitive)*** in response to passing opportunities of each link on the analysis network (Refer to Figure 5-11). The sensitivity analysis shows that only LOS categories A, B and E respond to passing opportunity changes on the network. Furthermore, the analysis shows that LOS category trigger volume values become insensitive (inelastic) to changes in passing opportunities once the percentage no-passing on a link exceeds 50%.

LOS category A is most responsive of all LOS categories showing on average a 13% change in LOS category trigger volume values from 0% to 30% no-passing on the network. LOS category A shows the highest reductions in trigger volume values between 0% and 30% no-passing (average 13% trigger volume reduction) on network links and again at 50% (7.9% trigger volume reduction), where after it becomes completely inelastic.

LOS category B only responds at a 10% no-passing level with a 1% reduction in trigger volume values. LOS E, similar to LOS A, is most responsive from 0% to 30% no-passing on the network showing on average a 1% change in LOS category trigger volume values.



Notes on Scenario Statistics: 10 scenarios, 5000 links, Linear increasing traffic volumes, Interval: 10% no-passing (10% reduction in passing opportunities) on the network link increase per scenario.

Source: Developed by Africon, 2010

Figure 5-11: Percentage No-passing – LOS Sensitivity Analysis Results

5.1.4 FONA Input Parameters

The GIS shape file was formatted as such that the transfer of the FONA information from the shape file to the model is a quick process. It is important to note that the link between the GIS and FONA in not lost during the running of the FONA model. The output of the FONA model is represented in the GIs file and MS Access database.

5.1.5 FONA Analysis Output Characteristics

Given the said Network Assumptions and Parameters (discussed in the previous Sections of this report), the FONA Analysis Output Characteristics are summarised in Table 5-2 below. Table 5-2 also provides corresponding Map references in order to describe visually and spatially each output characteristic of the EAC Road Network.

Table 5-2: FONA Analysis Output Characteristics Summary

No.	Data Field	Description	Range	EAC Road Network Characteristics	Map Reference
1.	Lanes	Number of lanes (Base year scenario)	1 to 4 lanes	1 Lane = 98% of total EAC Road Network 2 Lane = 2% of total EAC Road Network	Map 5-1: EAC Regional Road Network – Number of Travel Lanes and Terrain Type
2.	Lane_width	Lane width (m)	3.0m to 3.9m	Total EAC Road Network is assumed to be 3.5m in width per lane	Map 5-2: EAC Regional Road Network – Lane Width and Lateral Clearance
3.	Verge_width_L	Lateral clearance distance to obstacle next to road	0m to 1.8m	A lateral clearance of 1.8m was assumed for the Total EAC Road Network	Map 5-3: EAC Regional Road Network – Opposing Flow and Percentage of Links with No Passing Opportunities
4.	Verge_width_R				
5.	Opp. Flow	Opposing Flow (Same hour as 30th Highest Hourly Volume)	0 to 2000	• 0-200 30th Highest Hourly Volume per direction constitutes 90% (16,337.89km) of the total EAC Road Network • 201-500 30th Highest Hourly Volume per direction constitutes 7% (1,352.40km) of the total EAC Road Network • 501-2000 30th Highest Hourly Volume per direction constitutes 3% (478.82km) of the total EAC Road Network	Map 5-3: EAC Regional Road Network – Opposing Flow and Percentage of Links with No Passing Opportunities
6.	%HV	% Heavy vehicles in traffic stream (Base year scenario)	0% to 100%	• 59% (10,736.11km) of the total EAC Road Network operates with 20% Heavy Vehicles • 22% (4,038.07km) of the total EAC Road Network operates with 50% Heavy Vehicles • 19% (3,394.93km) of the total EAC Road Network operates with 75% Heavy Vehicles	Map 5-4: EAC Regional Road Network – Percentage Heavy Vehicles in Traffic Stream and Base Free Flow Speed
7.	%RV	% Recreational vehicles in traffic stream	0% to 50%	• 1% (268.87km) of the total EAC Road Network operates with 0.5% Recreational Vehicles • 99% (17,900.24km) of the total EAC Road Network operates with 5.0% Recreational Vehicles	Map 5-5: EAC Regional Road Network – Percentage Recreational Vehicles in Traffic Stream and Driver Population Indicator
8.	PHF	Peak Hour Factor	0 to 1.0	• 94% (17,042.96km) of the total EAC Road Network operates with a PHF of 0.88 • 6% (1,126.15km) of the total EAC Road Network operates with a PHF of 0.92	Map 5-6: EAC Regional Road Network – Peak Hour Factor and Number of Accesses per Kilometre

No.	Data Field	Description	Range	EAC Road Network Characteristics	Map Reference
9.	Terrain	Terrain type (proxy for link gradient)	Level to Mountainous	• Level terrain constitutes 40% (7,183.69km) of the total EAC Road Network • Mountainous terrain constitutes 2% (399.14km) of the total EAC Road Network • Rolling terrain constitutes 58% (10,586.28km) of the total EAC Road Network	Map 5-1: EAC Regional Road Network – Number of Travel Lanes and Terrain Type
10.	Driver_Pop (fp)	Driver Population Indicator	0.85 to 1.0	• 94% of the driver population in the EAC represents seasonal, non-local driver compositions and non-commuter drivers in the traffic stream • 6% of the driver population in the EAC represents commuter traffic with local drivers in the traffic stream	Map 5-5: EAC Regional Road Network – Percentage Recreational Vehicles in Traffic Stream and Driver Population Indicator
11.	LOA/km	Number of accesses per kilometre of link	0 to 24 Accesses	• 0 LOA/km = 15,975.23km (87.9%) • 1 LOA/km = 1,056.12km (5.8%) • 2 LOA/km = 619.97km (3.4%) • 3 LOA/km = 153.86km (1.0%) • >4 LOA/km = 333.93km (1.9%)	Map 5-6: EAC Regional Road Network – Peak Hour Factor and Number of Accesses per Kilometre
12.	BFFS	Base Free Flow Speed	>70km/h <100km/h	• 14.7% (2,672.90km) of the EAC Road Network operates at a Base Free Flow Speed of 70km/h • 46.9% (8,527.89km) of the EAC Road Network operates at a Base Free Flow Speed of 80km/h • 38.4% (6,968.32km) of the EAC Road Network operates at a Base Free Flow Speed of 90km/h	Map 5-4: EAC Regional Road Network – Percentage Heavy Vehicles in Traffic Stream and Base Free Flow Speed
13.	%No_Pass	% of link with no passing opportunities	0% to 90%	• 20% of links with no passing opportunities constitutes 7,183.69km (39.5%) of the total EAC Road Network • 50% of links with no passing opportunities constitutes 10,586.28km (58.3%) of the total EAC Road Network • 80% of links with no passing opportunities constitutes 388.14km (2.2%) of the total EAC Road Network	Map 5-3: EAC Regional Road Network – Opposing Flow and Percentage of Links with No Passing Opportunities

Source: Africon, 2010

98% of the EAC Road Corridor Network consists of 1 Lane per direction

2% of the EAC Road Corridor Network consists of 2 Lanes per direction

Level terrain constitutes 40% (7,183.69km) of the total EAC Road Network

Mountainous terrain constitutes 2% (399.14km) of the total EAC Road Network

Rolling terrain constitutes 58% (10,586.28km) of the total EAC Road Network

Map 5-1: EAC Regional Road Network – Number of Travel Lanes and Terrain Type

Total EAC Road Network is assumed to be 3.5m in width per lane with a lateral clearance of 1.8m as a result of sensitivity analysis.

Map 5-2: EAC Regional Road Network – Lane Width and Lateral Clearance

0-200 30th Highest Hourly Volume per direction constitutes 90% (16,337.89km) of the total EAC Road Network

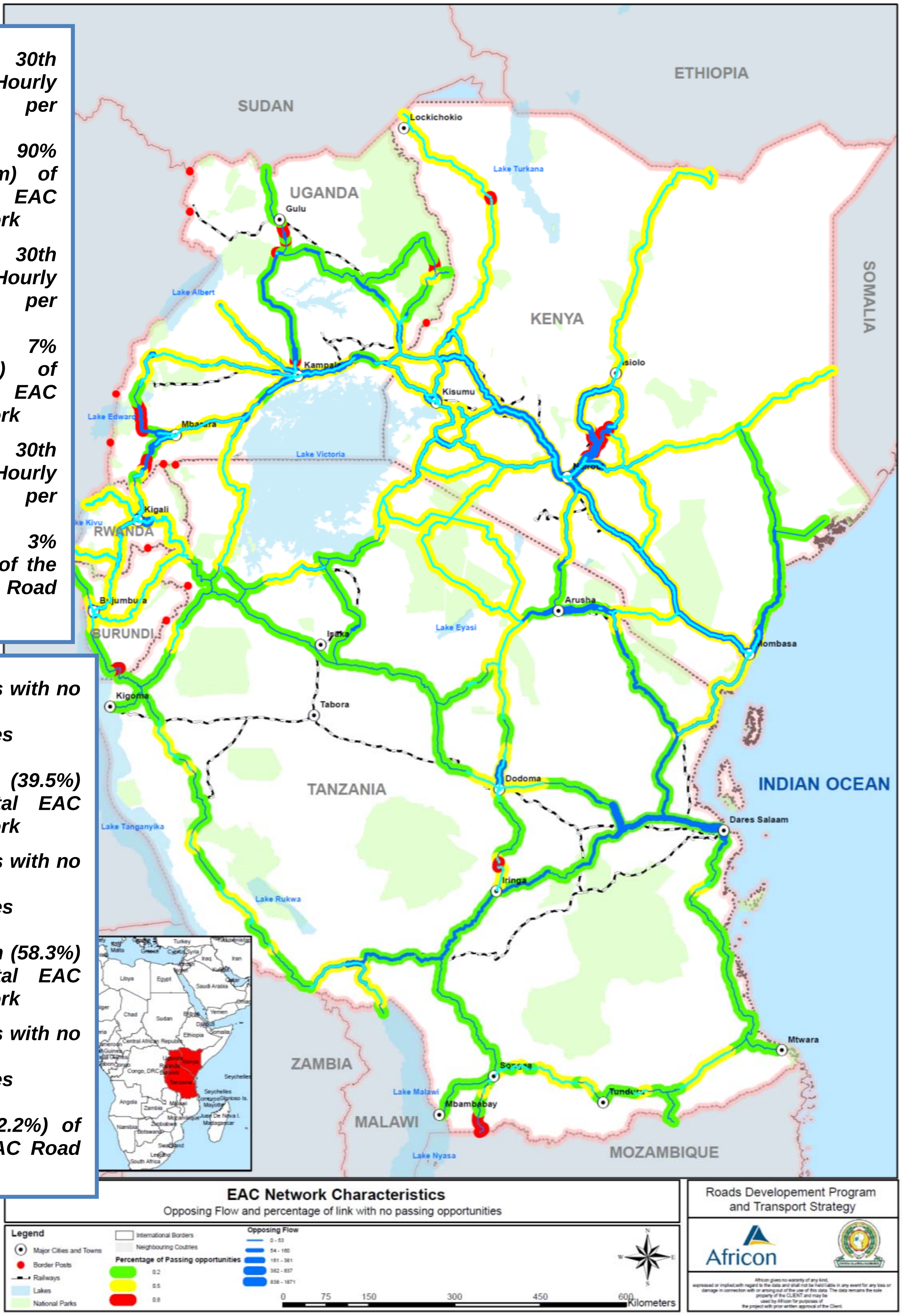
201-500 30th Highest Hourly Volume per direction constitutes 7% (1,352.40km) of the total EAC Road Network

501-2000 30th Highest Hourly Volume per direction constitutes 3% (478.82km) of the total EAC Road Network

20% of links with no passing opportunities constitutes 7,183.69km (39.5%) of the total EAC Road Network

50% of links with no passing opportunities constitutes 10,586.28km (58.3%) of the total EAC Road Network

80% of links with no passing opportunities constitutes 388.14km (2.2%) of the total EAC Road Network



Map 5-3: EAC Regional Road Network – Opposing Flow and Percentage of Links with No Passing Opportunities

59% (10,736.11km) of the total EAC Road Network operates with 20% Heavy Vehicles

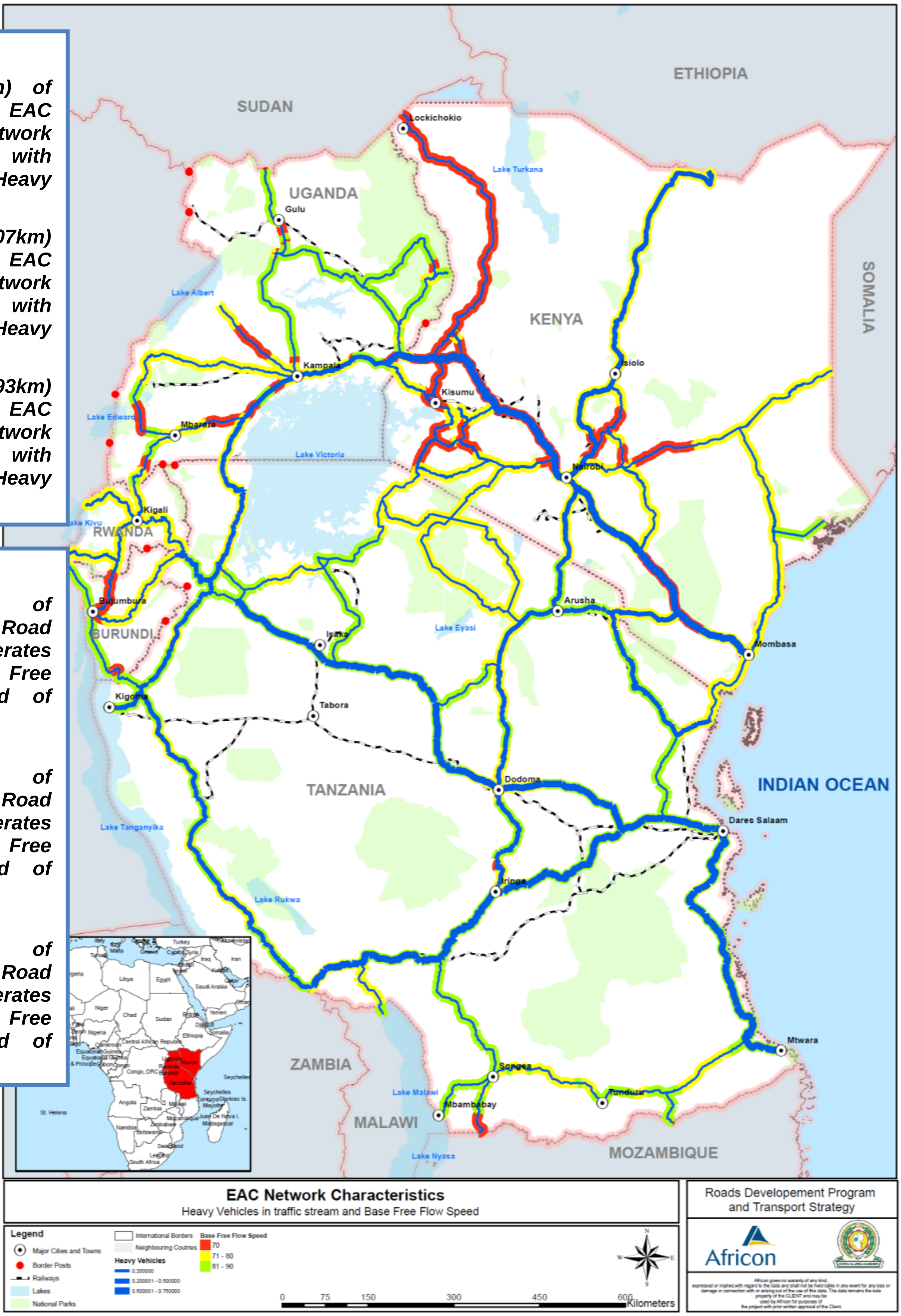
22% (4,038.07km) of the total EAC Road Network operates with 50% Heavy Vehicles

19% (3,394.93km) of the total EAC Road Network operates with 75% Heavy Vehicles

14.7% (2,672.90km) of the EAC Road Network operates at a Base Free Flow Speed of 70km/h

46.9% (8,527.89km) of the EAC Road Network operates at a Base Free Flow Speed of 80km/h

38.4% (6,968.32km) of the EAC Road Network operates at a Base Free Flow Speed of 90km/h



Map 5-4: EAC Regional Road Network – Percentage Heavy Vehicles in Traffic Stream and Base Free Flow Speed

1% (268.87km) of the total EAC Road Network operates with 0.5% Recreational Vehicles

99% (17,900.24km) of the total EAC Road Network operates with 5.0% Recreational Vehicles

94% of the driver population in the EAC represents seasonal, non-local driver compositions and non-commuter drivers in the traffic stream

6% of the driver population in the EAC represents commuter traffic with local drivers in the traffic stream

Map 5-5: EAC Regional Road Network – Percentage Recreational Vehicles in Traffic Stream and Driver Population Indicator

94% (17,042.96km) of the total EAC Road Network operates with a PHF of 0.88

6% (1,126.15km) of the total EAC Road Network operates with a PHF of 0.92

0 LOA/km = 15,975.23km (87.9%)

1 LOA/km = 1,056.12km (5.8%)

2 LOA/km = 619.97km (3.4%)

3 LOA/km = 153.86km (1.0%)

>4 LOA/km = 333.93km (1.9%)

Map 5-6: EAC Regional Road Network – Peak Hour Factor and Number of Accesses per Kilometre

5.2 FONA Results

The following sections of the report provide details of the FONA results in terms of the following Scenarios (given the abovementioned assumptions and parameters) for the EAC Road Network (for the EAC as a whole, per EAC Member State and per EAC Road Corridor):

- 2010 base year
- 2020 5% traffic growth
- 2020 8% traffic growth

5.2.1 EAC FONA Results – All Scenarios

Table 5-3 and Figure 5-12 below represent the summary of EAC FONA results for all scenarios.

Table 5-3: EAC – Percentage Road Network Length Operating at Level of Service Intervals

Scenarios	A	B	C	D	E	F	TOTAL
2010 Base Year	1.3%	34.4%	39.0%	16.4%	8.7%	0.1%	100%
2020 5% Growth	0.8%	33.6%	35.3%	17.4%	12.2%	0.7%	100%
2020 8% Growth	0.6%	30.9%	35.3%	18.5%	11.9%	2.8%	100%

Source: FONA Results, Africon 2010

With regards to Table 5-3 above, the following observations can be made:

- The 2010 Base Year Scenario shows that the EAC Road Network is operating at acceptable levels with only 8.7% and 0.1% of the total length operating at a LOS E and F respectively.
- The 2020 5% Growth Scenario shows an increase in EAC Road Network operating at LOS D, E and F (17.4%, 12.2% and 0.7% respectively).
- The 2020 8% Growth Scenario shows a further increase in EAC Road Network operating at LOS D, E, and F (18.5%, 11.9% and 2.8% respectively).

The above results are depicted graphically in Figure 5-12 below and spatially in Map 5-7, Map 5-8, and Map 5-9 below.

With regards to Map 5-7: FONA Results – Base Year 2010 Scenario, the following is noted:

- The most noteworthy Base Year 2010 results are located along the Northern Corridor showing LOS E around Mombasa, Voi, Naivasha, Nakuru, Molo, Eldoret, Bungoma, Bugiri, Kampala, and Masaka.
- The Namanga Corridor operates at a LOS E around Fort Hall, Embu, Nairobi in Kenya and at Dodoma in Tanzania.
- The Sirari Corridor demonstrates LOS E on sections around Kitale, Kakamega, Kisumu, and Kisii.
- The Central Corridor shows a LOS E on the section around Dar es Salaam.

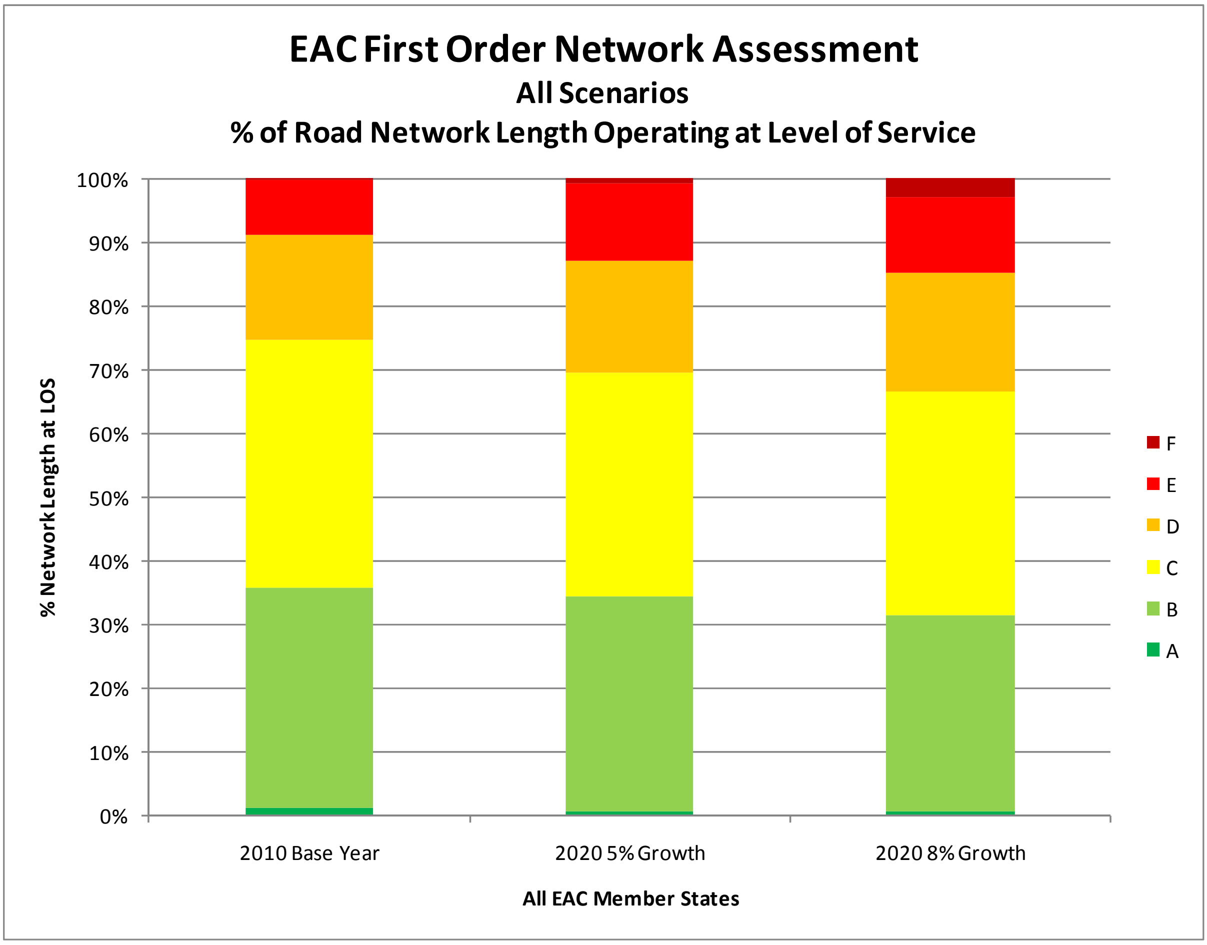
With regards to Map 5-8: FONA Results – Scenario 2020 5% Growth, the following is noted:

- The most noteworthy results are again located along the Northern Corridor showing a clear expansion on LOS E around Mombasa, Voi, Naivasha, Nakuru, Molo, Eldoret, Bungoma, Bugiri, Kampala, Masaka, Mbarara, Nyakibale, Kisoro and Kigali.
- Similarly, the Namanga Corridor operating at a LOS E is expanded around Fort Hall, Embu, Nairobi, Athi River, Kajiado and around Dodoma.

- The Sirari Corridor confirms a LOS E expansion on sections around Kitale, Kakamega, Kisumu, and Kisii.
- The Central Corridor shows expanded LOS E on sections around Dar es Salaam including LOS F.

With regards to Map 5-9: FONA Results – Scenario 2020 8% Growth, the following is noted:

- The most noteworthy results are again located along the Northern Corridor similar to the previous Scenario but including sections operating at LOS F around Mombasa, Naivasha, Nakuru, Molo, and Kampala.
- The Namanga Corridor operating at a LOS E is expanded around Fort Hall, Embu, and Kajiado. The Namanga Corridor operates at LOS F around Nairobi, Athi River and Dodoma.
- The Sirari Corridor confirms a LOS E expansion on sections around Kitale, Kakamega, Kisumu, and Kisii.
- The Central Corridor shows a LOS F around Dar es Salaam.



Source: FONA Calculation Results, Africon, 2010

Figure 5-12: EAC First Order Network Assessment Results – All Scenarios

Map 5-7: FONA Results – Base Year 2010 Scenario

Map 5-8: FONA Results – Scenario 2020 5% Growth

Map 5-9: FONA Results – Scenario 2020 8% Growth

5.2.2 FONA Results per EAC Member State

5.2.2.1 Burundi FONA Results – All Scenarios

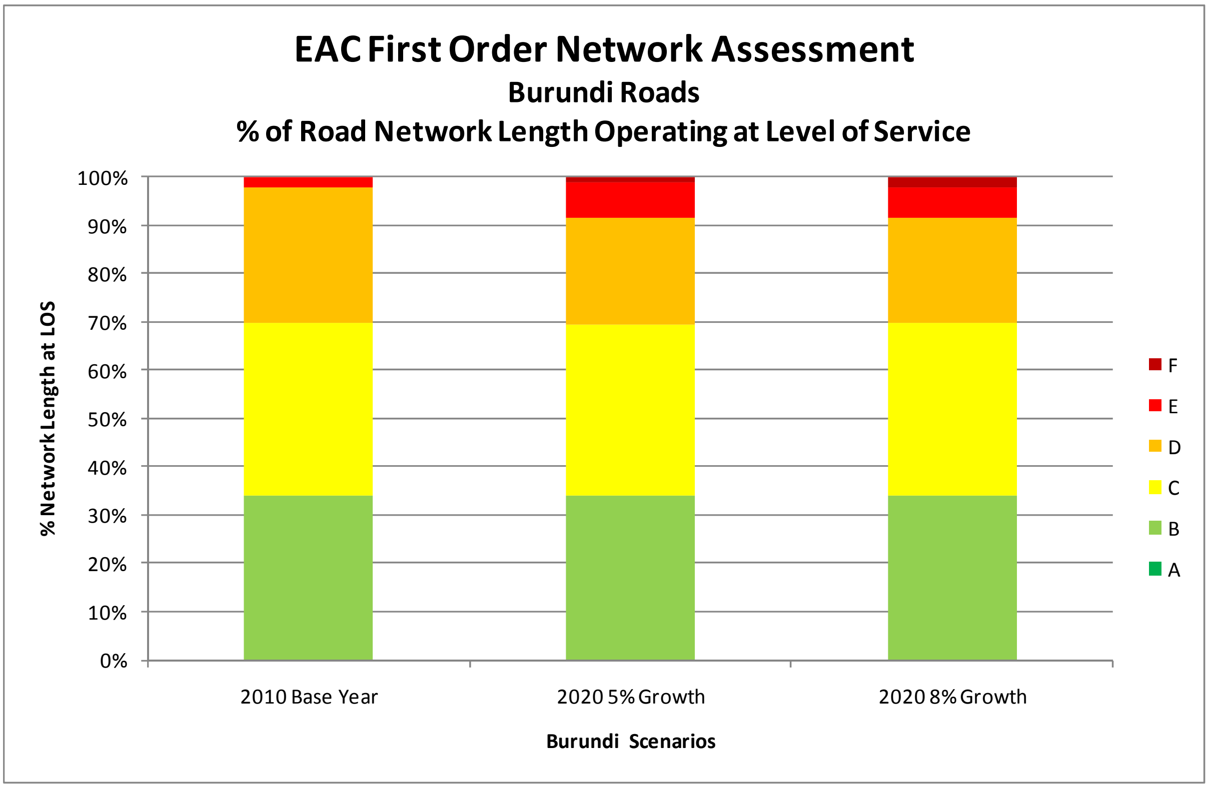
Table 5-4 below represents the percentage road length operating at LOS intervals for Burundi for all Scenarios.

Table 5-4: Burundi – Percentage Road Network Length Operating at LOS Intervals

BURUNDI							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.0%	34.0%	35.8%	28.3%	2.0%	0.0%	100%
2020 5% Growth	0.0%	34.0%	35.8%	22.1%	7.2%	1.3%	100%
2020 8% Growth	0.0%	34.0%	35.8%	21.8%	6.6%	2.0%	100%

Source: FONA Results, Africon 2010

Figure 5-13 below demonstrates graphically the percentage road length operating at LOS intervals for Burundi for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-13: Burundi – Percentage Road Network Length Operating at LOS Intervals

5.2.2.2 Kenya FONA Results – All Scenarios

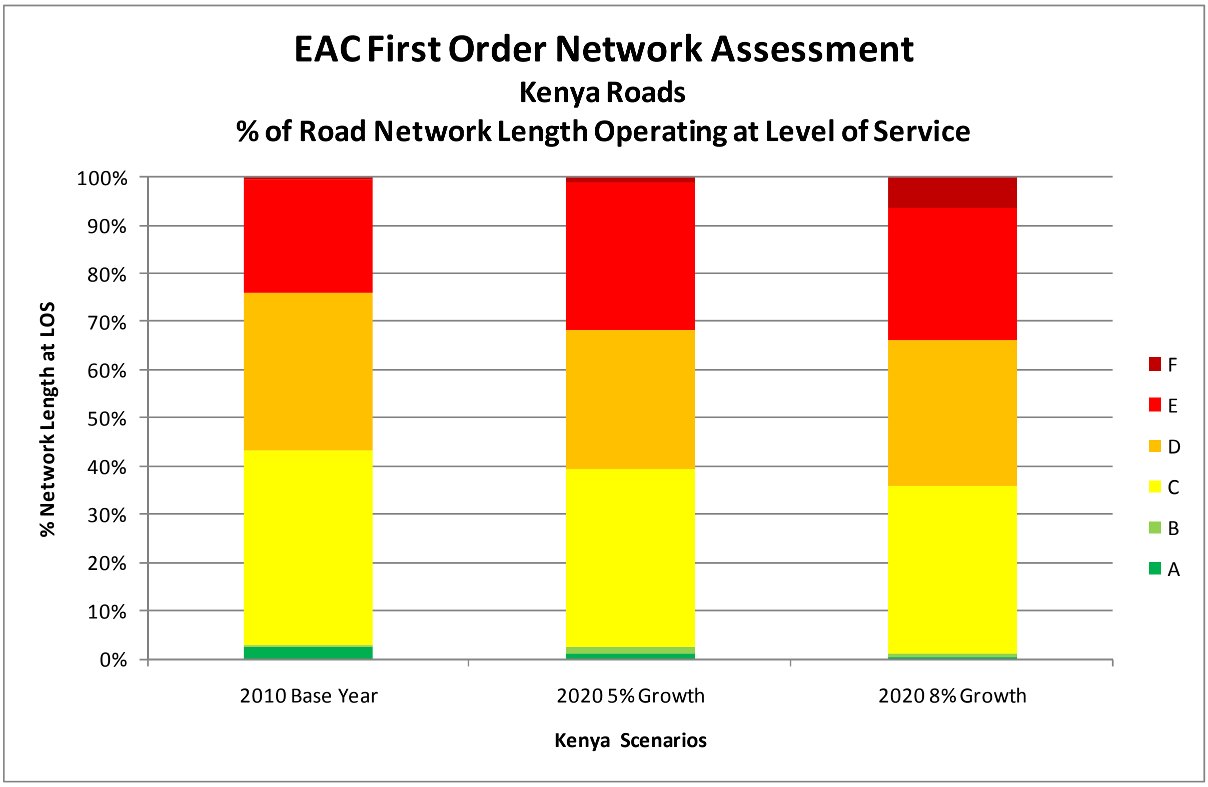
Table 5-5 below represents the percentage road length operating at LOS intervals for Kenya for all Scenarios.

Table 5-5: Kenya – Percentage Road Network Length Operating at LOS Intervals

KENYA							
Scenarios	A	B	C	D	E	F	TOTAL
2010 Base Year	2.6%	0.2%	40.7%	32.7%	23.6%	0.4%	100%
2020 5% Growth	1.2%	1.3%	36.8%	28.8%	30.6%	1.3%	100%
2020 8% Growth	0.5%	0.8%	34.5%	30.4%	27.4%	6.5%	100%

Source: FONA Results, Africon 2010

Figure 5-14 below represents graphically the percentage road length operating at LOS intervals for Kenya for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-14: Kenya – Percentage Road Network Length Operating at LOS Intervals

5.2.2.3 Rwanda FONA Results – All Scenarios

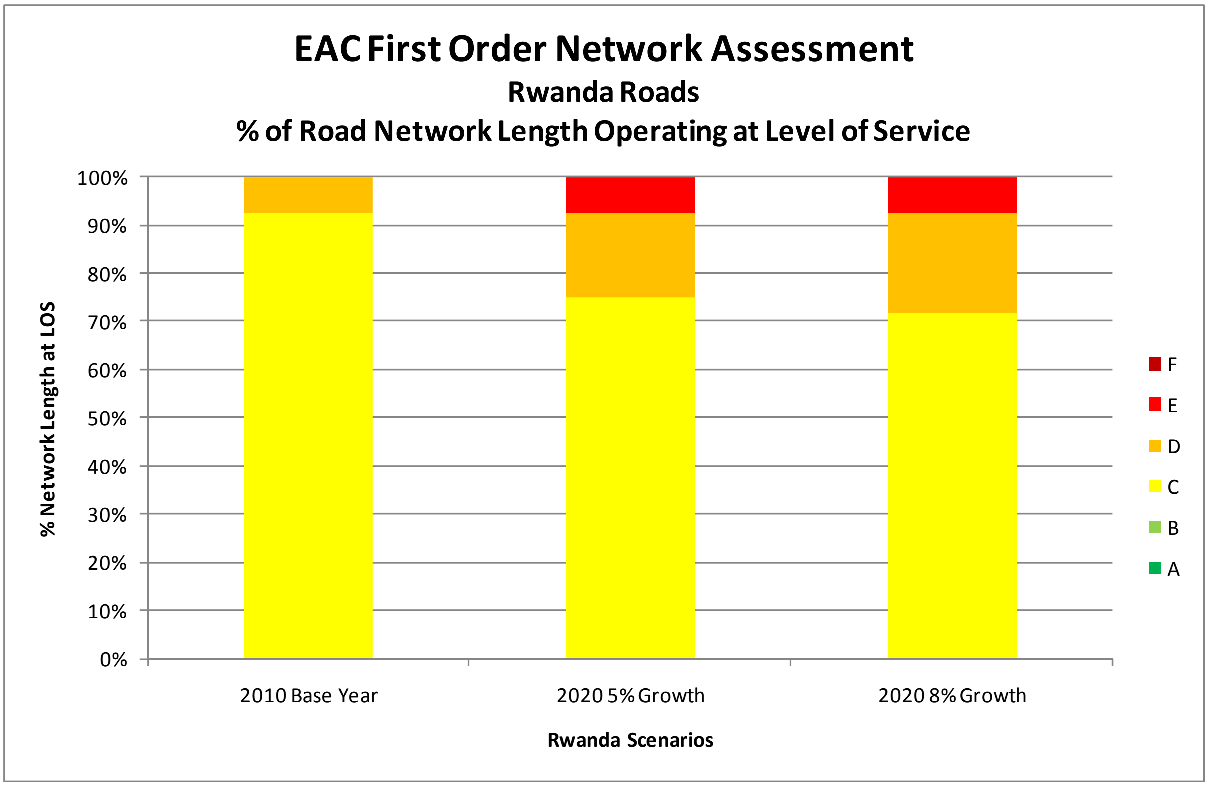
Table 5-6 below represents the percentage road length operating at LOS intervals for Rwanda for all Scenarios.

Table 5-6: Rwanda – Percentage Road Network Length Operating at LOS Intervals

RWANDA							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.0%	0.0%	92.4%	7.6%	0.0%	0.0%	100%
2020 5% Growth	0.0%	0.0%	74.9%	17.6%	7.6%	0.0%	100%
2020 8% Growth	0.0%	0.0%	71.9%	20.7%	7.6%	0.0%	100%

Source: FONA Results, Africon 2010

Figure 5-15 below represents graphically the percentage road length operating at LOS intervals for Rwanda for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-15: Rwanda – Percentage Road Network Length Operating at LOS Intervals

5.2.2.4 Tanzania FONA Results – All Scenarios

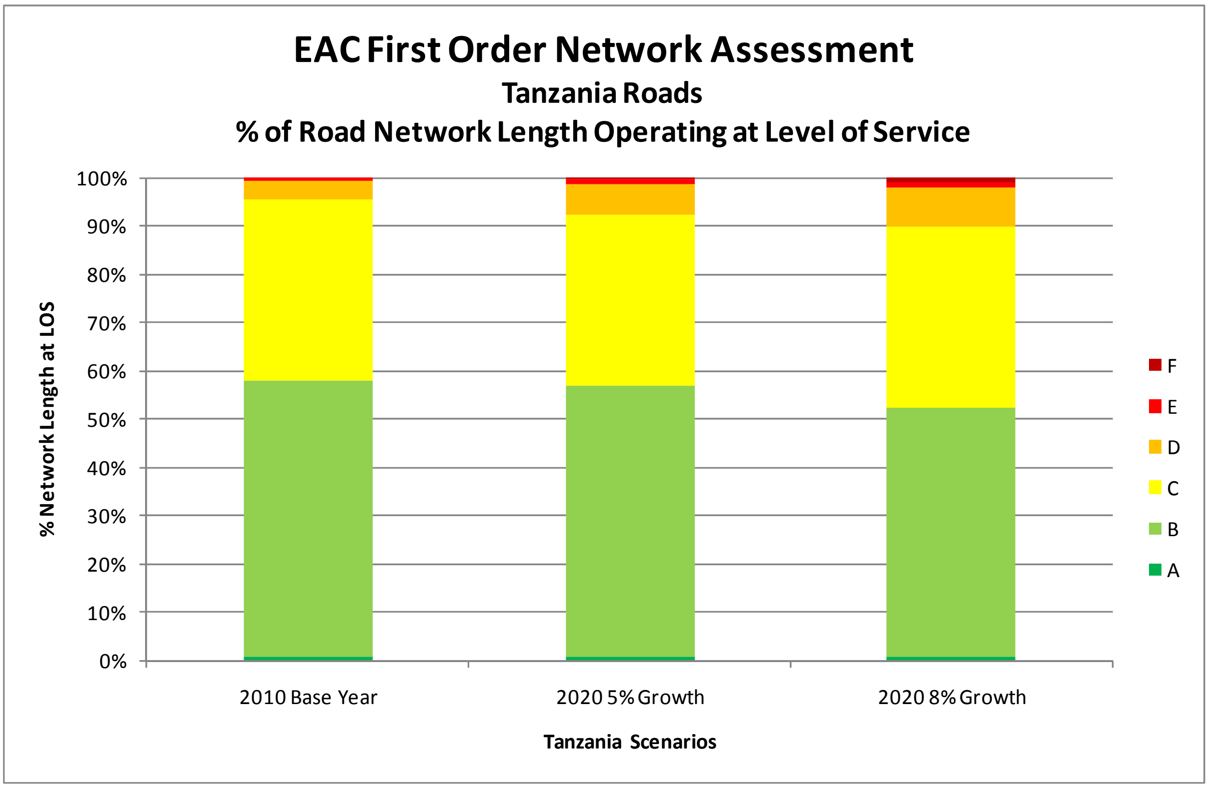
Table 5-7 below represents the percentage road length operating at LOS intervals for Tanzania for all Scenarios.

Table 5-7: Tanzania – Percentage Road Network Length Operating at LOS Intervals

TANZANIA							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.8%	57.4%	37.5%	3.7%	0.8%	0.0%	100%
2020 5% Growth	0.7%	56.0%	35.5%	6.3%	1.2%	0.3%	100%
2020 8% Growth	0.7%	51.6%	37.4%	8.0%	1.2%	1.0%	100%

Source: FONA Results, Africon 2010

Figure 5-16 below represents graphically the percentage road length operating at LOS intervals for Tanzania for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-16: Tanzania – Percentage Road Network Length Operating at LOS Intervals

5.2.2.5 Uganda FONA Results – All Scenarios

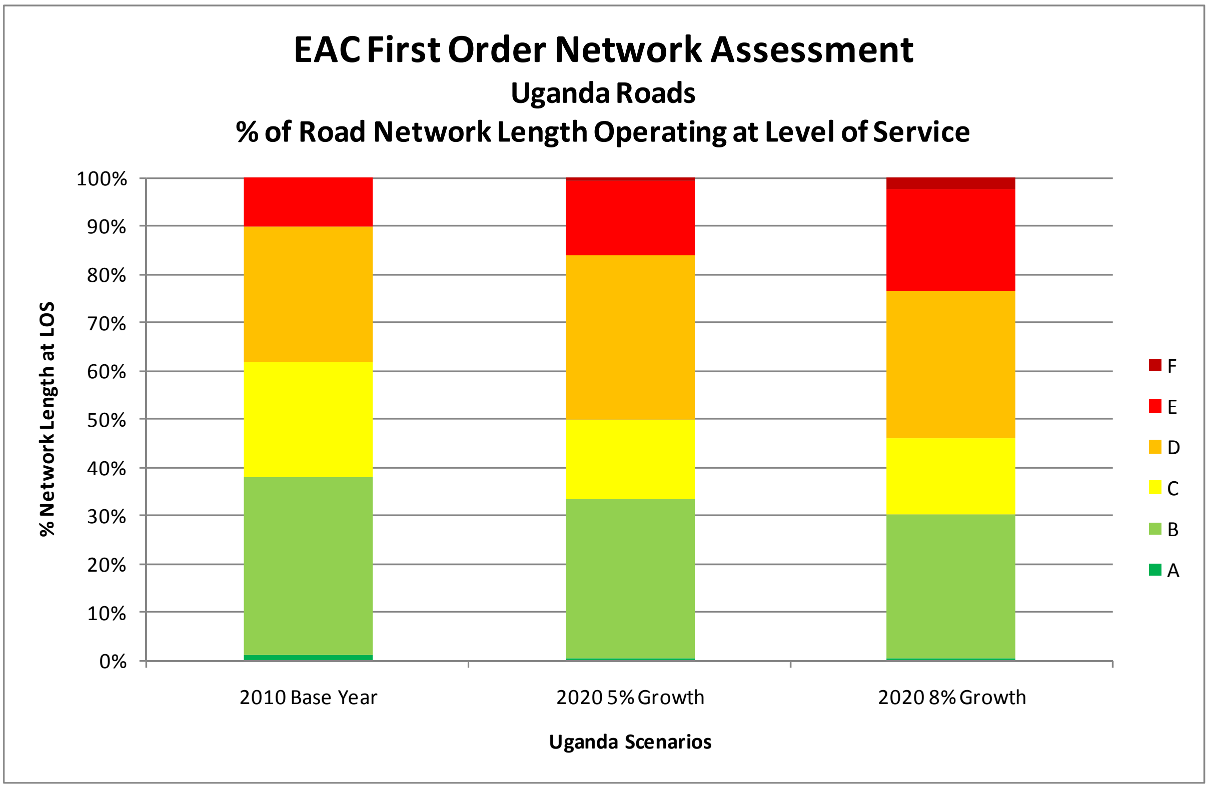
Table 5-8 below represents the percentage road length operating at LOS intervals for Uganda for all Scenarios.

Table 5-8: Uganda – Percentage Road Network Length Operating at LOS Intervals

UGANDA							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	1.3%	36.7%	23.8%	28.1%	10.2%	0.0%	100%
2020 5% Growth	0.4%	33.0%	16.6%	34.1%	15.3%	0.7%	100%
2020 8% Growth	0.4%	29.8%	15.8%	30.6%	21.1%	2.5%	100%

Source: FONA Results, Africon 2010

Figure 5-17 below represents graphically the percentage road length operating at LOS intervals for Uganda for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-17: Uganda – Percentage Road Network Length Operating at LOS Intervals

5.2.3 FONA Results per EAC Corridor

5.2.3.1 Northern Corridor – All Scenarios

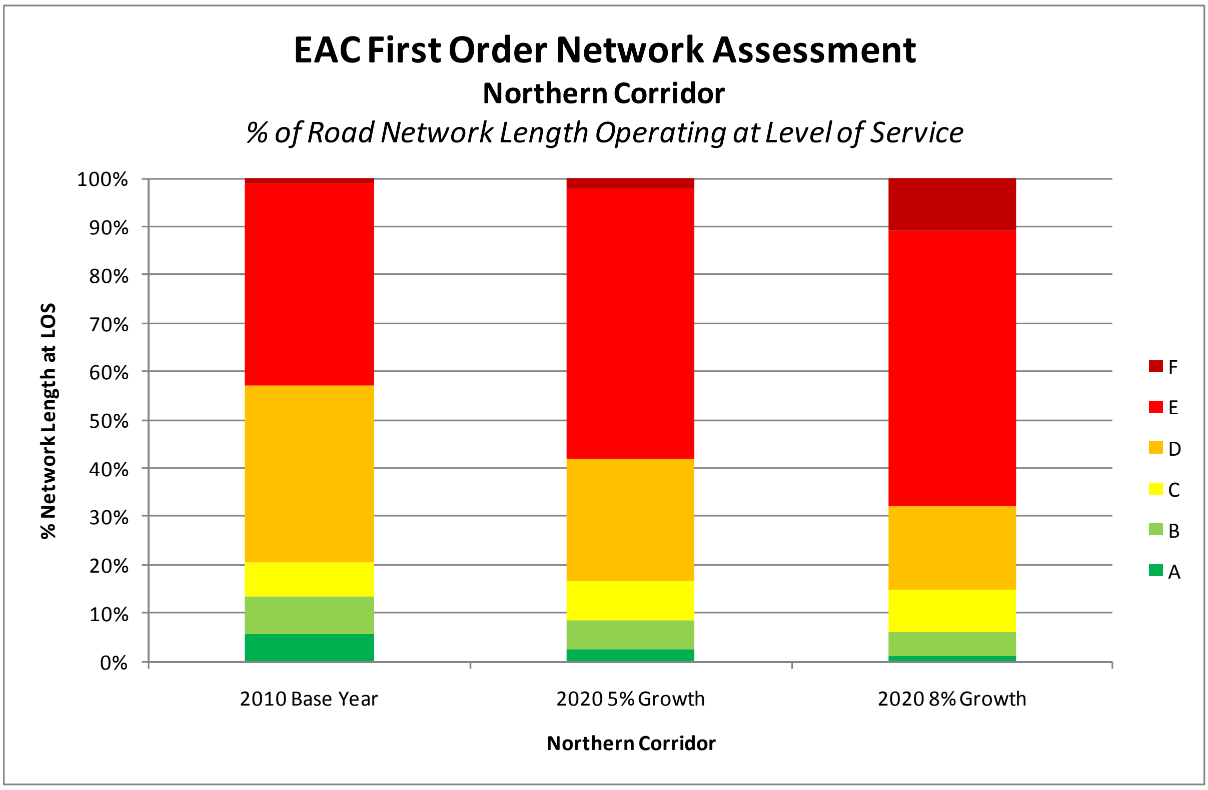
Table 5-9 below represents the percentage road length operating at LOS intervals for the Northern Corridor for all Scenarios.

Table 5-9: Northern Corridor Road Network Length Operating at LOS Intervals – All Scenarios

NORTHERN CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	5.7%	7.6%	7.1%	36.7%	41.9%	1.0%	100%
2020 5% Growth	2.6%	5.9%	8.3%	25.1%	55.9%	2.2%	100%
2020 8% Growth	1.0%	5.0%	8.9%	17.3%	57.1%	10.7%	100%

Source: FONA Results, Africon 2010

Figure 5-18 below represents graphically the percentage road length operating at LOS intervals for the Northern Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-18: Northern Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.2 Central Corridor – All Scenarios

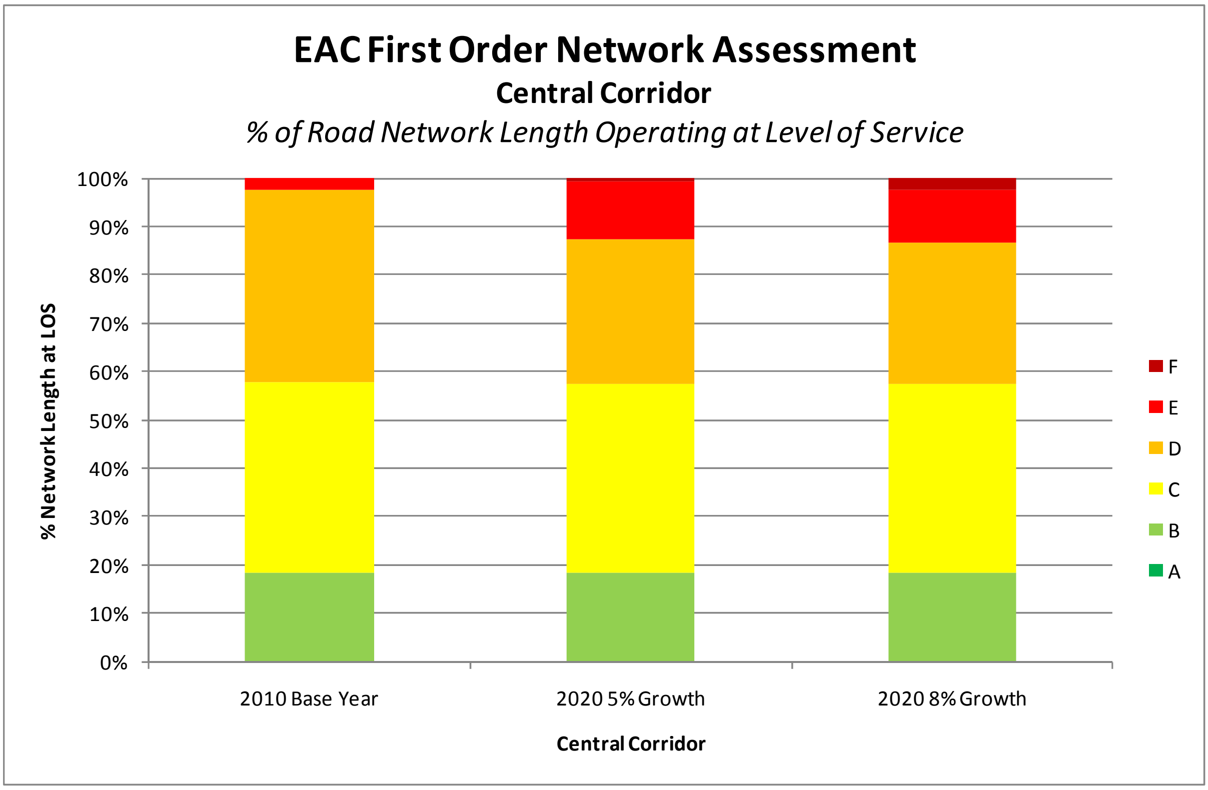
Table 5-10 below represents the percentage road length operating at LOS intervals for the Central Corridor for all Scenarios.

Table 5-10: Central Corridor Road Network Length Operating at LOS Intervals – All Scenarios

CENTRAL CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.0%	18.5%	39.2%	39.8%	2.5%	0.0%	100%
2020 5% Growth	0.0%	18.5%	39.1%	29.8%	11.8%	0.8%	100%
2020 8% Growth	0.0%	18.5%	39.1%	29.2%	10.7%	2.5%	100%

Source: FONA Results, Africon 2010

Figure 5-19 below represents graphically the percentage road length operating at LOS intervals for the Central Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-19: Central Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.3 Dar es Salaam (TAZARA) Corridor – All Scenarios

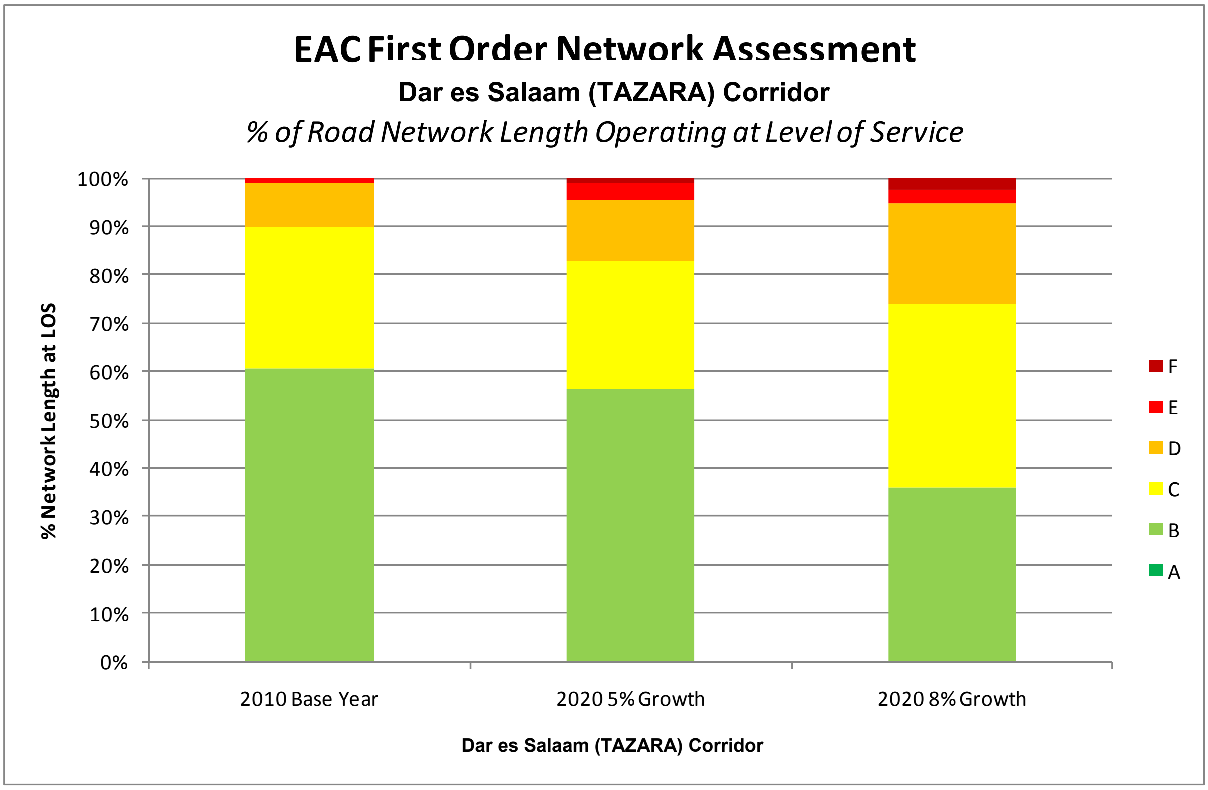
Table 5-11 below represents the percentage road length operating at LOS intervals for the Dar es Salaam (TAZARA) Corridor for all Scenarios.

Table 5-11: Dar es Salaam (TAZARA) Corridor Road Network Length Operating at LOS Intervals – All Scenarios

DAR ES SALAAM (TAZARA) CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.0%	60.7%	29.1%	9.1%	1.0%	0.0%	100%
2020 5% Growth	0.0%	56.4%	26.2%	12.7%	3.7%	1.0%	100%
2020 8% Growth	0.0%	36.1%	38.0%	20.5%	3.0%	2.3%	100%

Source: FONA Results, Africon 2010

Figure 5-20 below represents graphically the percentage road length operating at LOS intervals for the Dar es Salaam (TAZARA) Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-20: Dar es Salaam (TAZARA) Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.4 Namanga Corridor – All Scenarios

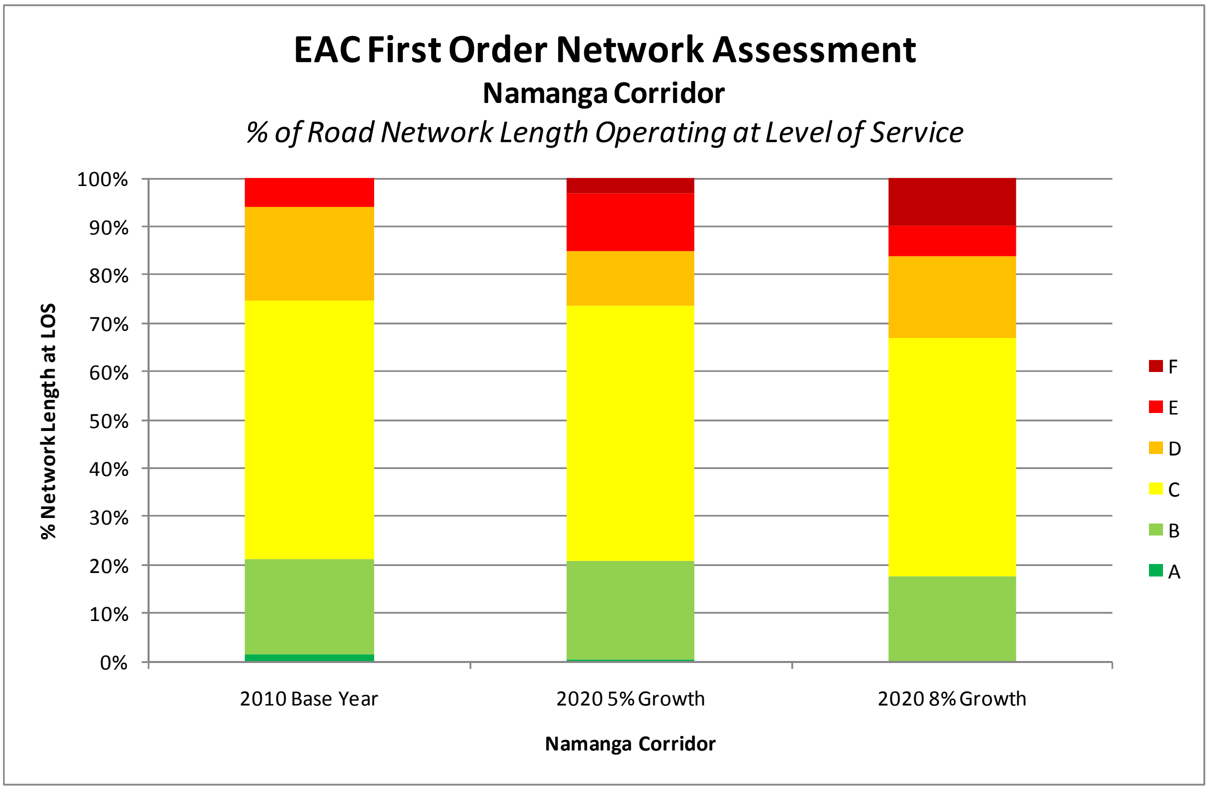
Table 5-12 below represents the percentage road length operating at LOS intervals for the Namanga Corridor for all Scenarios.

Table 5-12: Namanga Corridor Road Network Length Operating at LOS Intervals – All Scenarios

NAMANGA CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	1.4%	19.8%	53.4%	19.4%	6.0%	0.0%	100%
2020 5% Growth	0.6%	20.4%	52.7%	11.2%	11.9%	3.3%	100%
2020 8% Growth	0.0%	17.5%	49.3%	17.2%	6.3%	9.7%	100%

Source: FONA Results, Africon 2010

Figure 5-21 below represents graphically the percentage road length operating at LOS intervals for the Namanga Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-21: Namanga Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.5 Sumbawanga Corridor – All Scenarios

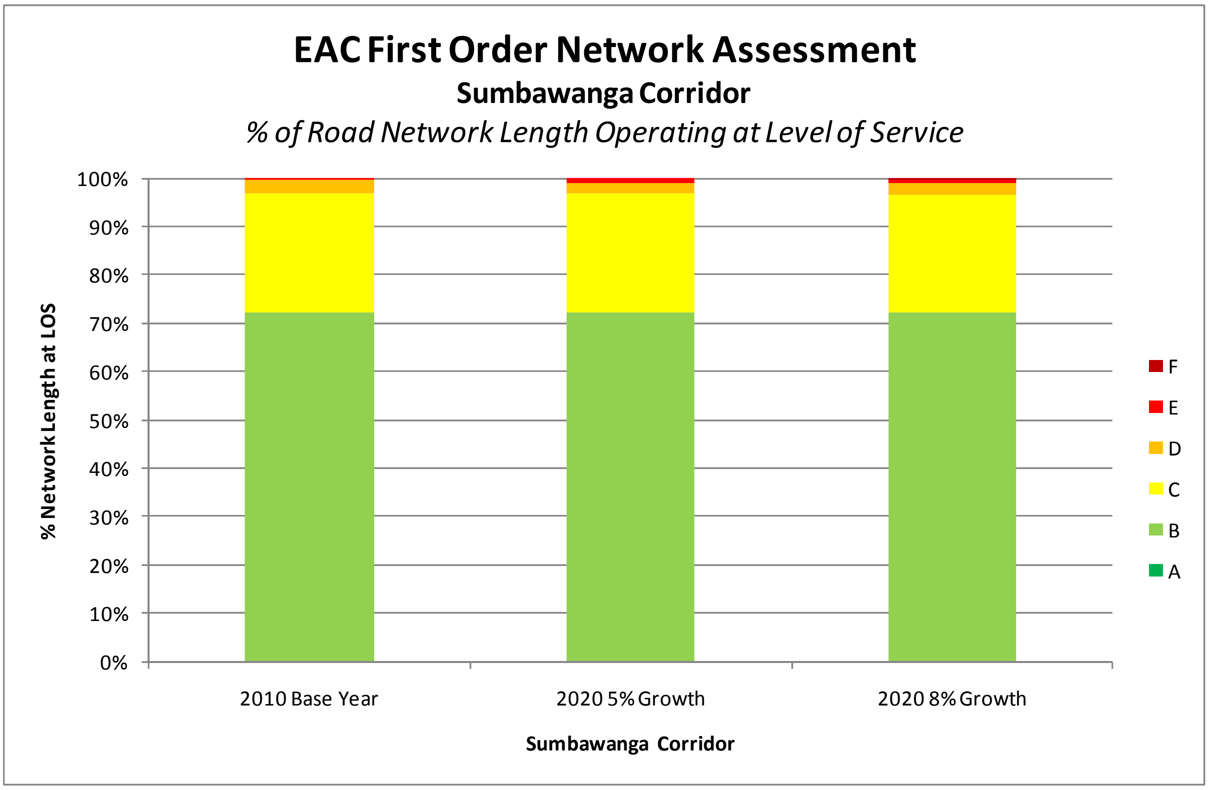
Table 5-13 below represents the percentage road length operating at LOS intervals for the Sumbawanga Corridor for all Scenarios.

Table 5-13: Sumbawanga Corridor Road Network Length Operating at LOS Intervals – All Scenarios

SUMBAWANGA CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.0%	72.3%	24.4%	2.8%	0.5%	0.0%	100%
2020 5% Growth	0.0%	72.3%	24.4%	2.4%	0.9%	0.0%	100%
2020 8% Growth	0.0%	72.3%	24.3%	2.4%	0.5%	0.5%	100%

Source: FONA Results, Africon 2010

Figure 5-22 below represents graphically the percentage road length operating at LOS intervals for the Sumbawanga Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-22: Sumbawanga Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.6 Sirari Corridor – All Scenarios

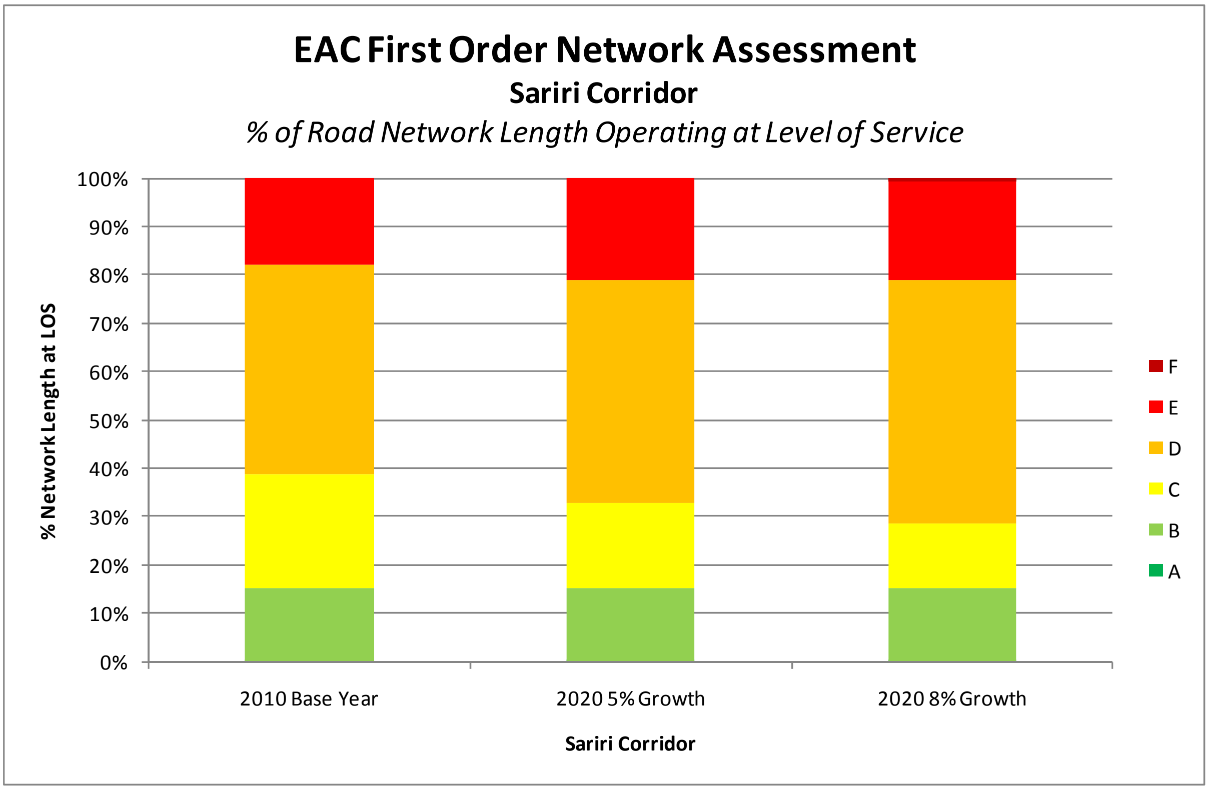
Table 5-14 below represents the percentage road length operating at LOS intervals for the Sirari Corridor for all Scenarios.

Table 5-14: Sirari Corridor Road Network Length Operating at LOS Intervals – All Scenarios

SIRARI CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.1%	15.2%	23.5%	43.1%	18.0%	0.0%	100%
2020 5% Growth	0.1%	15.2%	17.5%	46.2%	21.0%	0.0%	100%
2020 8% Growth	0.1%	15.2%	13.2%	50.5%	20.4%	0.6%	100%

Source: FONA Results, Africon 2010

Figure 5-23 below represents graphically the percentage road length operating at LOS intervals for the Sirari Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-23: Sirari Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.7 Coastal Corridor – All Scenarios

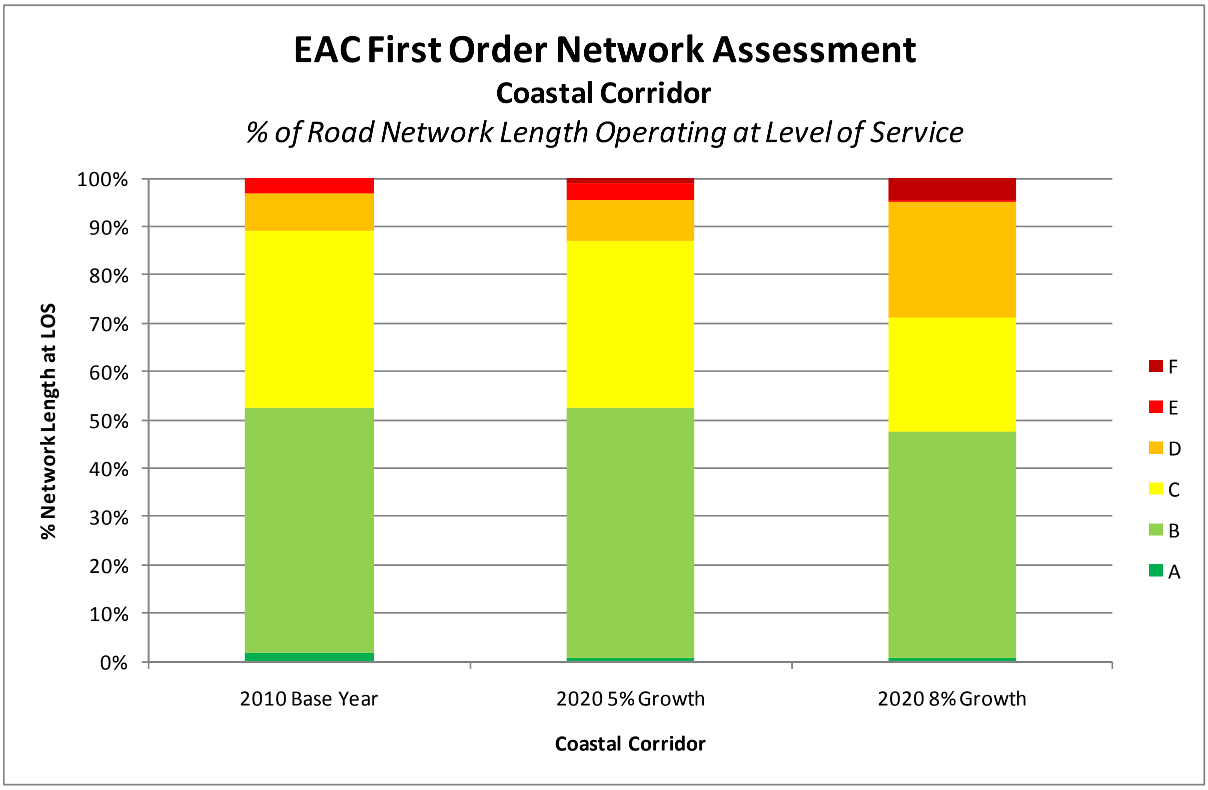
Table 5-15 below represents the percentage road length operating at LOS intervals for the Coastal Corridor for all Scenarios.

Table 5-15: Coastal Corridor Road Network Length Operating at LOS Intervals – All Scenarios

COASTAL CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	1.9%	50.7%	36.4%	7.9%	3.2%	0.0%	100%
2020 5% Growth	0.8%	51.7%	34.7%	8.4%	3.5%	1.0%	100%
2020 8% Growth	0.6%	47.0%	23.4%	24.0%	0.6%	4.4%	100%

Source: FONA Results, Africon 2010

Figure 5-24 below represents graphically the percentage road length operating at LOS intervals for the Coastal Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-24: Coastal Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.8 Mtwara Corridor – All Scenarios

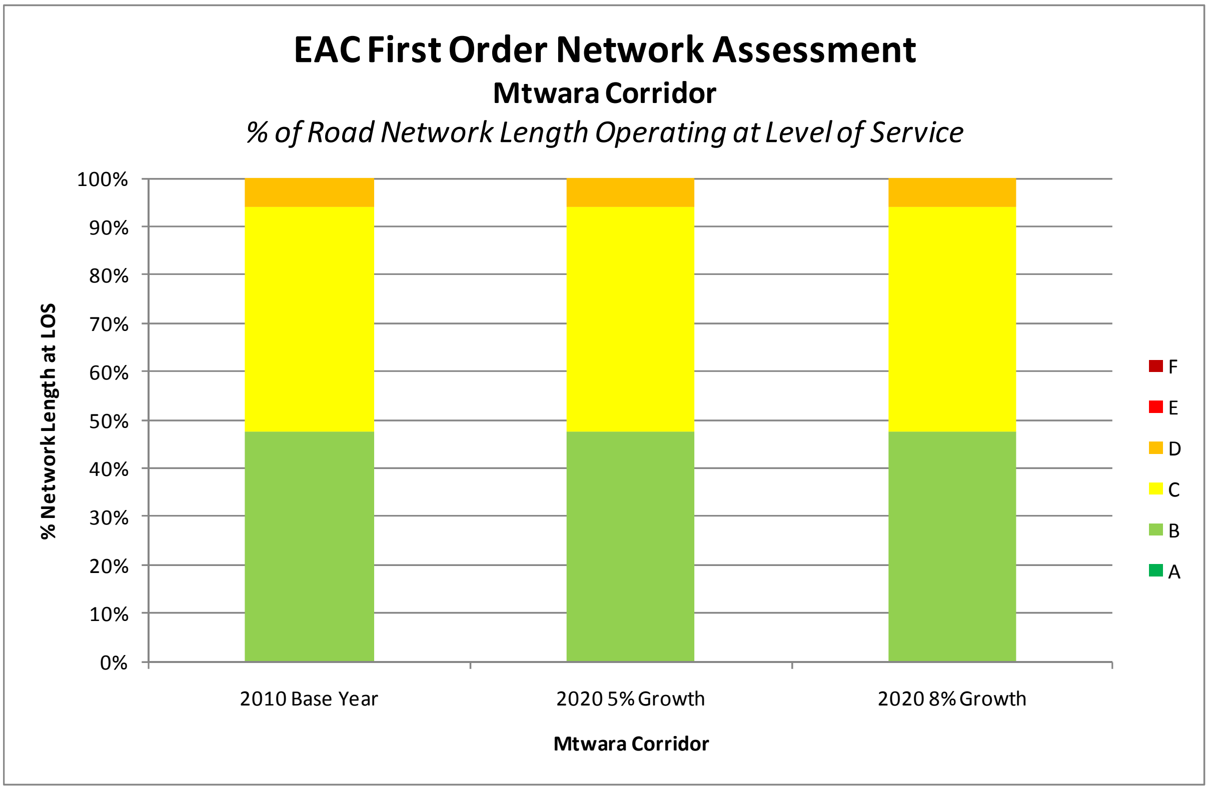
Table 5-16 below represents the percentage road length operating at LOS intervals for the Mtwara Corridor for all Scenarios.

Table 5-16: Mtwara Corridor Road Network Length Operating at LOS Intervals – All Scenarios

MTWARA CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.0%	47.5%	46.6%	5.9%	0.0%	0.0%	100%
2020 5% Growth	0.0%	47.5%	46.6%	5.9%	0.0%	0.0%	100%
2020 8% Growth	0.0%	47.5%	46.6%	5.9%	0.0%	0.0%	100%

Source: FONA Results, Africon 2010

Figure 5-25 below represents graphically the percentage road length operating at LOS intervals for the Mtwara Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-25: Mtwara Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.9 Arusha Corridor – All Scenarios

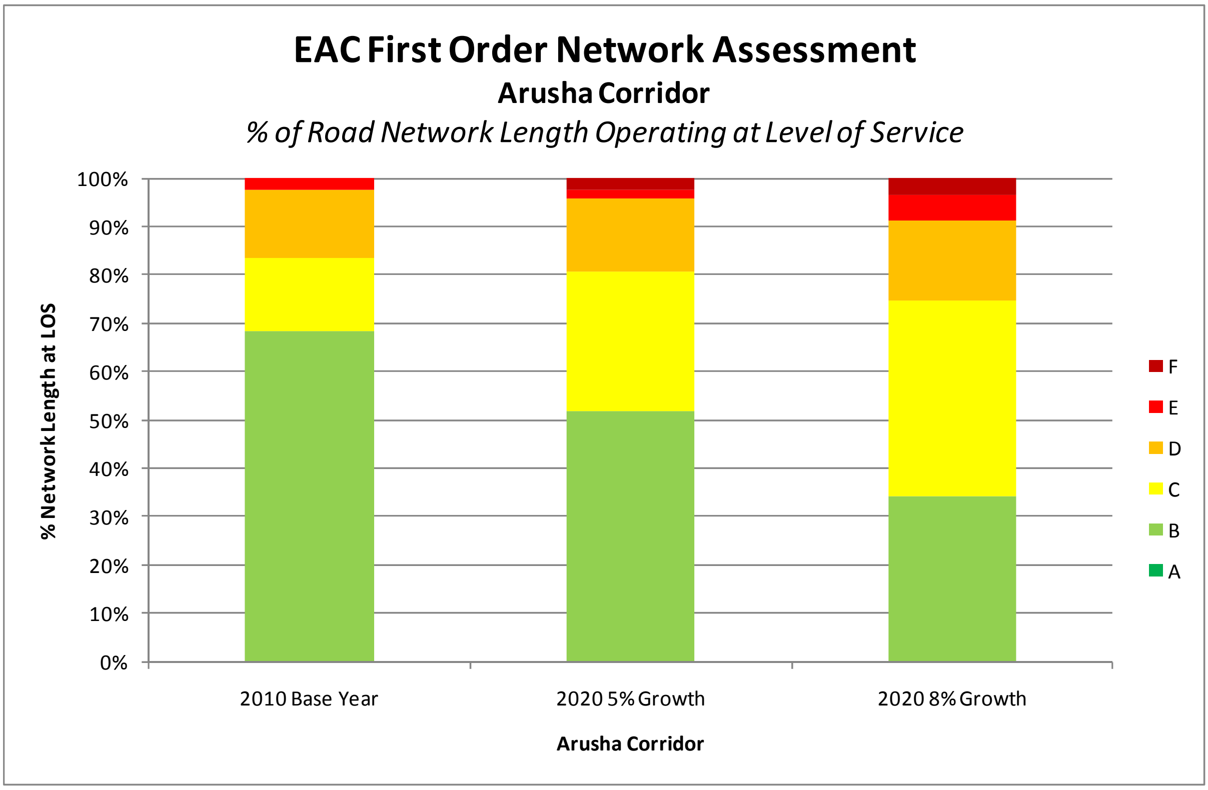
Table 5-17 below represents the percentage road length operating at LOS intervals for the Arusha Corridor for all Scenarios.

Table 5-17: Arusha Corridor Road Network Length Operating at LOS Intervals – All Scenarios

ARUSHA CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.0%	68.3%	15.2%	14.0%	2.4%	0.0%	100%
2020 5% Growth	0.0%	51.9%	28.8%	15.0%	1.9%	2.4%	100%
2020 8% Growth	0.0%	34.2%	40.6%	16.4%	5.5%	3.3%	100%

Source: FONA Results, Africon 2010

Figure 5-26 below represents graphically the percentage road length operating at LOS intervals for the Arusha Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-26: Arusha Corridor Road Network Length Operating at LOS Intervals – All Scenarios

5.2.3.10 Gulu Corridor – All Scenarios

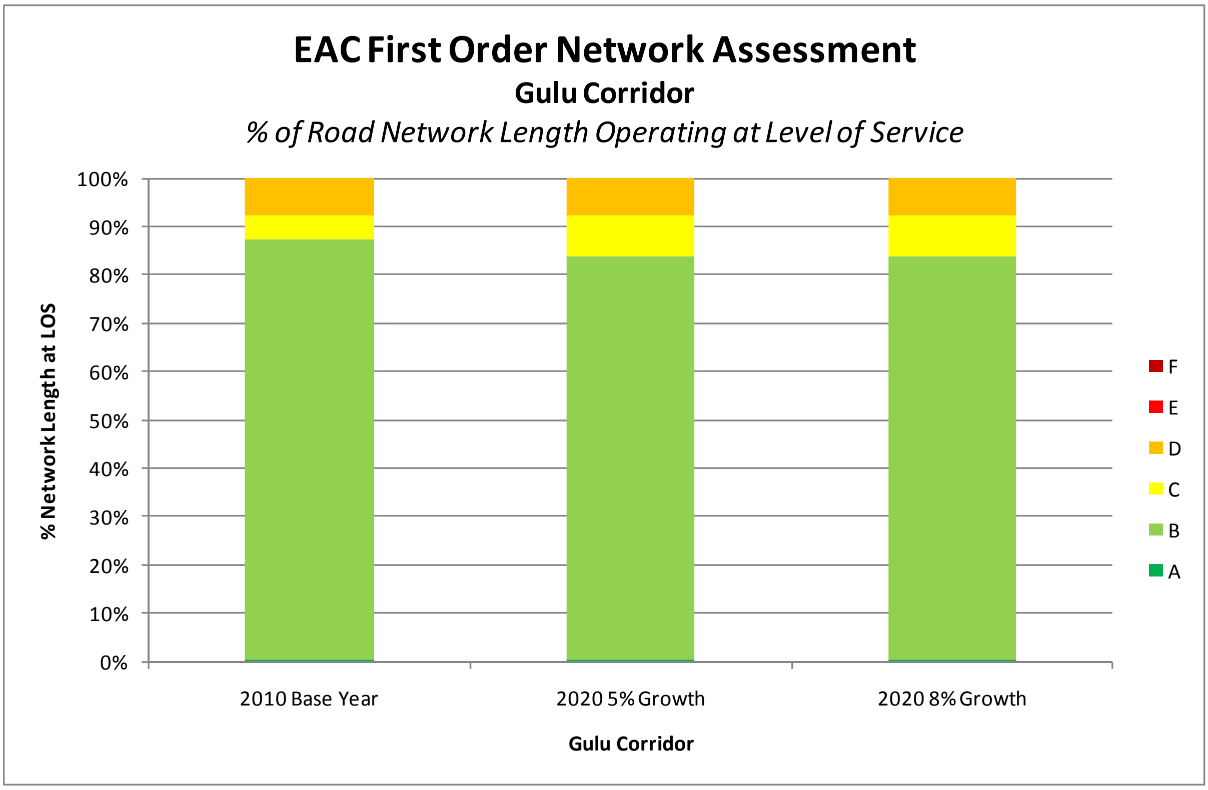
Table 5-18 below represents the percentage road length operating at LOS intervals for the Gulu Corridor for all Scenarios.

Table 5-18: Gulu Corridor Road Network Length Operating at LOS Intervals – All Scenarios

GULU CORRIDOR							
Scenarios	**A**	**B**	**C**	**D**	**E**	**F**	**TOTAL**
2010 Base Year	0.4%	87.1%	4.9%	7.6%	0.0%	0.0%	100%
2020 5% Growth	0.4%	83.4%	8.6%	7.6%	0.0%	0.0%	100%
2020 8% Growth	0.4%	83.4%	8.4%	7.8%	0.0%	0.0%	100%

Source: FONA Results, Africon 2010

Figure 5-27 below represents graphically the percentage road length operating at LOS intervals for the Gulu Corridor for all Scenarios.



Source: FONA Results, Africon 2010

Figure 5-27: Gulu Corridor Road Network Length Operating at LOS Intervals – All Scenarios

6. ROADS CONDITION

6.1 Background

This section of the report describes the road network, methodology and results of the analysis of the EAC road network. The objective of this analysis was to determine the current and future technical needs of the EAC road network, to promote a road network operating in a sound condition.

The activities addressed in this section are exclusively for rehabilitation of paved roads and upgrading of gravel roads to paved standards.

6.2 The Road Network Investigated

Data for the road network classified as the EAC corridor was obtained from two sources, namely:

- Primary source: Road assessment surveys performed by Africon (Geostrada).
- Secondary source: Road network data obtained from the Road/Pavement Management Systems (PMS or RMS) of each country's Road Authority.

6.2.1 Primary Source Condition Data

The primary source for the roads condition assessment was undertaken by means of video logging and assessing the road network by means of visual data. The process entailed driving along the target road with a video camera installed on the vehicle, capturing all pertinent roads data. The video feed is linked via GPS to a geographic information system (GIS). The system used is called 'Road Doctor', a product developed specifically for this purpose.

Where possible, condition data was sourced from road surveys conducted by Geostrada during 2010. The data collected during the surveys was used as the primary source of data; describing the current condition of the road network in terms of roughness, rut depths and other road deterioration indicators such as cracking, ravelling and potholes.

6.2.2 Secondary Source Condition Data

All data obtained from the management systems of the five countries was used as the secondary data source to supplement the primary data source. The data set was further enhanced with input from local experts.

More than 70% of the data was sourced from the clients' systems.

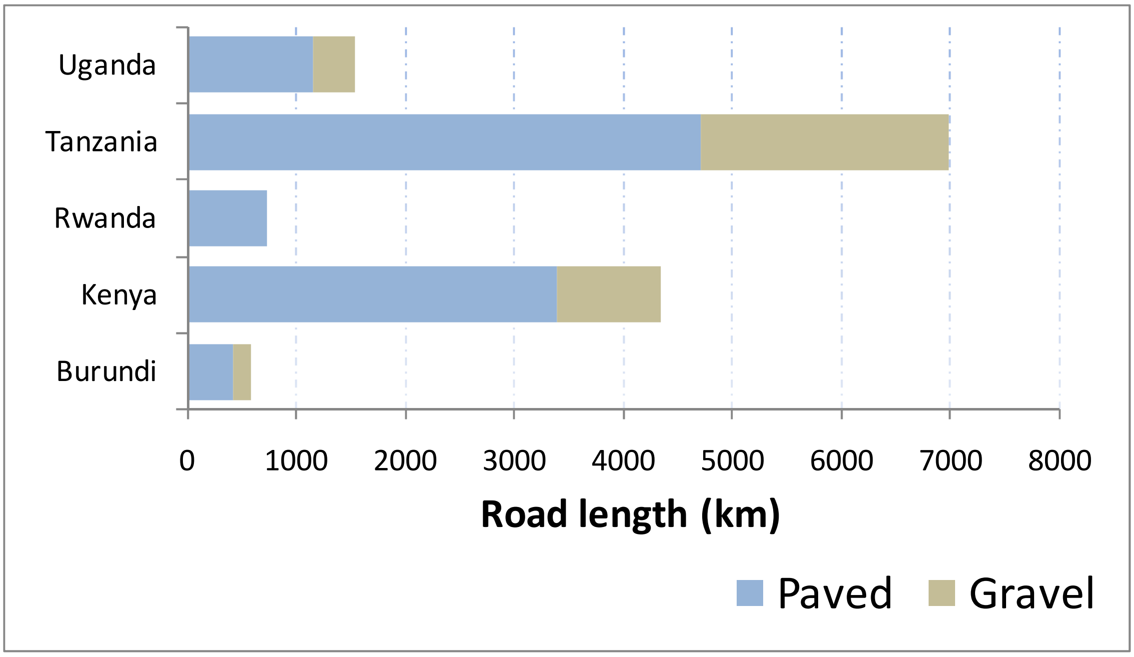
Table 6-1: The Road Network Length

Country	Paved Roads (Km)	Gravel Roads (Km)	Primary Source	Secondary Source
Burundi	427	166	76%	24%
Kenya	3,397	942	15%	85%
Rwanda	734	-	79%	21%
Tanzania	4,709	2,284	33%	67%
Uganda	1,160	380	5%	95%
TOTAL	**10,427 (73%)**	**3,771 (27%)**	**29%**	**71%**

Primary Source: Road assessment surveys performed by Africon (Geostrada).

Secondary Source: Road network data obtained from the Road/Pavement Management Systems (PMS or RMS) of each country's Road Authority.

Note: Lengths are approximate Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.



Source: Africon, 2010

Figure 6-1: EAC Road Network Length (Km) Investigated for their technical needs

6.2.3 Traffic

Seven per cent of the EAC corridor carries traffic in excess of 5 000 vehicles per day; these all are paved roads located across the five countries. The deterioration of the pavement structures of the high trafficked roads is expected to exceed the deterioration on the rest of the network due to the increased traffic loads.

Gravel roads constitute 27% of the total corridor length. Of these, approximately 715km (19%) carry traffic in excess of 200 vehicles per day and would typically be given priority when existing gravel roads are considered for upgraded to paved standards.

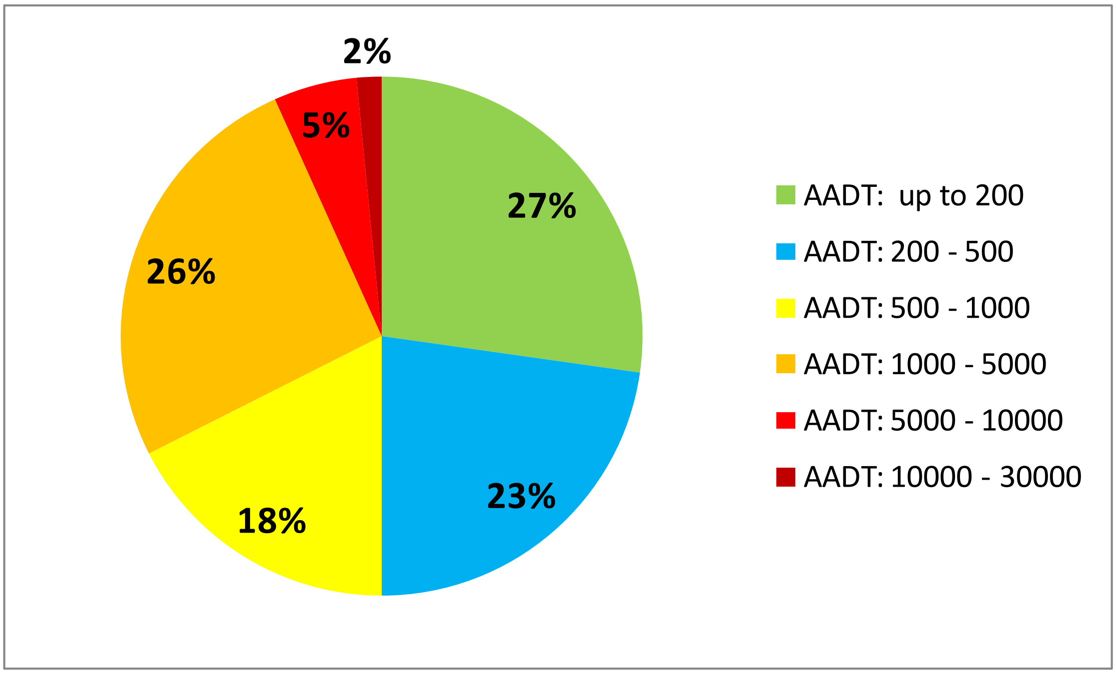


Figure 6-2: Traffic Distribution

6.2.4 The Current Condition Status of EAC Corridor

All data obtained from the primary and secondary sources were used to determine the current condition status of the pavement structures of the EAC corridor. The final data set therefore include measurements and survey assessments from both primary and secondary sources.

The first and foremost indicator of the pavements' condition was pavement roughness, also referred to as riding quality. This objective measurement describes the distortion of the pavement surface which contributes to an undesirable or uncomfortable ride. The unit for roughness is the International Roughness Index (IRI) ranging between 0 (Good) to 20 (Very Poor):

- Paved roads are typically maintained at roughness levels between 2 and 6 IRI. These roads require no immediate remedial action and are considered to be in a sound state.
- Paved roads that are approaching a severe state have typical roughness levels between 6 and 10 IRI. These roads are in warning state.
- Paved roads in a severe condition, requiring immediate remedial action have typical roughness levels above 10 IRI.

The second indicator of pavement condition was an overall condition index, also referred to as the Visual Condition Index (VCI). Visual assessments are a cost-effective method of gathering information to describe the functional and structural condition of a road's pavement. During a visual survey, the condition of the road is assessed as a percentage/rating for each of the distresses typically associated with road deterioration. For example, cracks develop due to weathering and traffic loading and they were recorded as a percentage of the road surface with cracks. During the post-processing phase, the distress data collected during the visual assessment survey are combined / calculated into an index representing the overall condition of the entire road segment. This index serves as a parameter to compare the condition of individual pavements and to communicate the health of a road segment and the road network.

At a national level, the condition statistics are normally reported into three categories, namely:

- **Sound**: These roads require no immediate remedial intervention, but preventive maintenance and routine maintenance should be done in accordance to proper road network maintenance policies. Roads included here are those in a very good condition, as well as roads showing signs of surface deterioration but no serious structural deterioration.
- **Warning**: These are normally roads requiring rehabilitation within the next 5 years. These roads have deteriorated beyond the point of effective preventive maintenance intervention, such as a reseal.
- **Severe**: The functional service level of the road is unacceptable requiring immediate remedial action to reinstate the road's pavement to a functional level.

In order to measure the current condition of the roads of the EAC corridor, both condition indicators (roughness and overall condition index) were combined into an overall status. This status categorised each road segment into a Sound, Warning or Severe category, representing the extent of the need for remedial action (rehabilitation). The status of each road segment then formed the basis to combine adjacent road segments into larger road sections based on pavement type, country and condition status. These larger road sections were then analysed for their technical needs, see following chapter.

- According to the condition indicators there are currently approximately 1 000km of paved roads requiring immediate remedial intervention to reinstate them to functional levels. Excessive road user costs prevail on these roads. Cost-effective measures such as reseals cannot be used to improve the functionality and performance of these roads.
- A further 1 700km of paved roads are currently operating under a 'warning' state, indicating a nearing need for rehabilitation due to pavement deterioration. In some cases cost-effective measures such as reseals can still be applied to delay the rate of deterioration.
- There are approximately 3 600km of road operating on gravel surfaces with huge economic consequences to road users. Due to the high operating costs associated with gravel roads, economic development and trade are not promoted.
- The remainder of the road network is operating at a functional level and it is supposed and recommended that these roads are maintained under a proper maintenance policy.

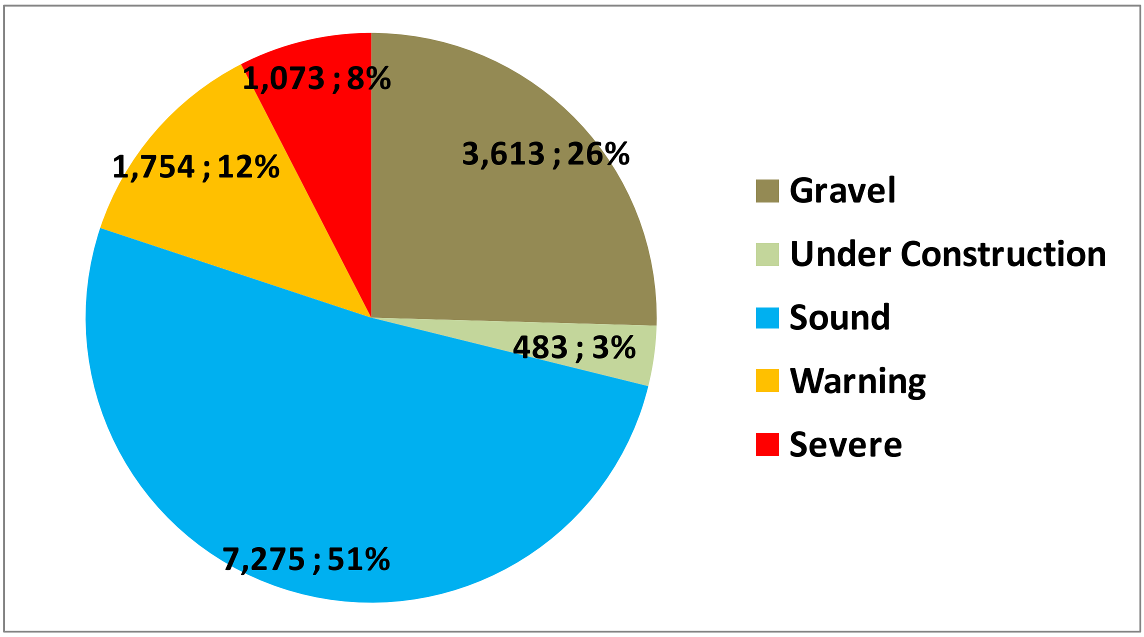


Figure 6-3: Status of EAC Corridor, 2010

Table 6-2: Road Status – 2010

Country	Road	From (km)	To (km)	Length (km)	Type	Status
Burundi	RN1_B	0.00	7.09	7.09	Paved	Sound
Burundi	RN1_B	7.09	113.68	106.59	Paved	Sound
Burundi	RN1_N1_B	0.00	0.44	0.44	Paved	Sound
Burundi	RN1_N2_B	0.00	0.10	0.10	Paved	Sound
Burundi	RN1_N3_B	0.00	0.14	0.14	Paved	Sound
Burundi	RN12_B	0.00	1.68	1.68	Paved	Sound
Burundi	RN12_B	1.68	94.00	92.32	Unpaved	Gravel
Burundi	RN16_B	0.00	6.00	6.00	Unpaved	Gravel
Burundi	RN18_B	0.00	48.71	48.71	Unpaved	Gravel

Country	Road	From (km)	To (km)	Length (km)	Type	Status
Burundi	RN3_B	0.00	0.70	0.70	Paved	Sound
Burundi	RN3_B	0.71	7.22	6.51	Paved	Sound
Burundi	RN3_B	7.22	146.60	139.38	Paved	Sound
Burundi	RN3_B	146.60	164.06	17.46	Unpaved	Gravel
Burundi	RN5_B	0.00	77.11	77.11	Paved	Warning
Burundi	RN5_B	77.11	84.24	7.13	Paved	Sound
Burundi	RN5_N_B	0.00	0.31	0.31	Paved	Sound
Burundi	RN6_B	0.00	1.31	1.31	Unpaved	Gravel
Burundi	RN6_B	1.31	28.43	27.12	Paved	Severe
Burundi	RN7_B	0.00	48.04	48.04	Paved	Sound
Burundi	RN8_B	0.00	4.92	4.92	Paved	Sound
Kenya	A1_K	0.00	29.10	29.10	Unpaved	Gravel
Kenya	A1_K	29.10	242.10	213.00	Paved	Severe
Kenya	A1_K	242.10	437.90	195.80	Paved	Severe
Kenya	A1_K	437.90	538.50	100.60	Paved	Severe
Kenya	A1_K	538.50	601.00	62.50	Paved	Severe
Kenya	A1_K	601.00	649.00	48.00	Paved	Severe
Kenya	A1_K	649.00	698.50	49.50	Paved	Severe
Kenya	A1_K	698.50	722.30	23.80	Paved	Sound
Kenya	A1_K	722.30	807.80	85.50	Paved	Warning
Kenya	A1_K	807.80	894.50	86.70	Paved	Warning
Kenya	A104_K	Malaba-Webuye		57.20	Paved	Severe
Kenya	A104_K	Webuye-Eldoret		57.69	Paved	Severe
Kenya	A104_K	Webuye-Eldoret		12.22	Paved	Severe
Kenya	A104_K	Timboroa - Mau Summit		38.70	Paved	Sound
Kenya	A104_K	Timboroa-Eldoret		64.10	Paved	Severe
Kenya	A104_K	Mau Summit - Njoro T'off - Lanet - Naivasha		113.00	Paved	Sound
Kenya	A104_K	Naivasha – Limuru		59.50	Paved	Warning
Kenya	A104_K	Limuru - Museum Hill		34.00	Paved	Severe
Kenya	A104_K	Museum Hill - JKIA - Athi River		24.10	Paved	Sound
Kenya	A104_K	403.30	463.04	59.74	Paved	Severe
Kenya	A104_K	463.04	599.73	136.70	Paved	Warning
Kenya	A109_K	0.00	9.91	9.91	Paved	Warning / Need Reseal
Kenya	A109_K	9.91	46.21	36.30	Paved	Sound
Kenya	A109_K	46.21	100.21	54.00	Paved	Severe

Country	Road	From (km)	To (km)	Length (km)	Type	Status
Kenya	A109_K	100.21	249.21	149.00	Paved	Warning / Need Reseal
Kenya	A109_K	249.21	281.93	32.72	Paved	Sound
Kenya	A109_K	281.93	406.98	125.05	Paved	Sound
Kenya	A109_K	406.98	457.41	50.43	Paved	Sound
Kenya	A14_K	0.00	106.43	106.43	Paved	Severe
Kenya	A2_K	0.00	83.01	83.01	Paved	Sound
Kenya	A2_K	83.01	285.32	202.31	Paved	Sound
Kenya	A2_K	285.32	772.34	487.02	Unpaved	Gravel
Kenya	A2_N_K	0.00	31.06	31.06	Paved	Sound
Kenya	A23_K	0.00	3.63	3.63	Unpaved	Gravel
Kenya	A23_K	3.64	113.51	109.88	Paved	Warning
Kenya	A3_K	0.00	78.83	78.83	Paved	Sound
Kenya	A3_K	78.83	124.86	46.03	Paved	Warning
Kenya	A3_K	124.86	321.16	196.30	Paved	Sound
Kenya	A3_K	321.16	428.21	107.06	Unpaved	Gravel
Kenya	A3_K	428.21	520.74	92.53	Unpaved	Gravel
Kenya	B6_K	0.00	123.04	123.04	Paved	Sound
Kenya	B6_N_K	0.00	39.00	39.00	Paved	Sound
Kenya	B7_K	0.00	81.28	81.28	Paved	Sound
Kenya	B7_K	81.28	131.38	50.10	Paved	Sound
Kenya	B7_K	131.38	276.77	145.40	Unpaved	Gravel
Kenya	B8_K	0.00	130.07	130.07	Paved	Sound
Kenya	B8_K	130.07	202.93	72.86	Unpaved	Gravel
Kenya	B8_K	202.93	353.64	150.71	Paved	Sound
Kenya	B8_K	353.64	448.76	95.12	Paved	Sound
Kenya	C88	Naivasha-Maai Mahiu		37.00	Paved	Sound
Kenya	C88	Maai Mahiu – Rironi		19.50	Paved	Warning
Rwanda	RN1_R	0.00	0.26	0.26	Paved	Sound
Rwanda	RN1_R	0.26	0.28	0.02	Paved	Sound
Rwanda	RN1_R	0.28	2.49	2.21	Paved	Sound
Rwanda	RN1_R	2.49	2.70	0.21	Paved	Sound
Rwanda	RN1_R	2.70	21.42	18.72	Paved	Sound
Rwanda	RN1_R	21.43	155.07	133.64	Paved	Sound
Rwanda	RN12_R	0.00	4.84	4.84	Paved	Sound
Rwanda	RN2_R	0.00	3.25	3.25	Paved	Sound
Rwanda	RN2_R	3.25	7.02	3.77	Paved	Sound
Rwanda	RN2_R	7.02	34.92	27.90	Paved	Sound

Country	Road	From (km)	To (km)	Length (km)	Type	Status
Rwanda	RN2_R	34.93	49.44	14.51	Paved	Warning
Rwanda	RN2_R	49.44	77.34	27.90	Paved	Sound
Rwanda	RN3_N_R	0.00	0.23	0.23	Paved	Sound
Rwanda	RN3_R	0.00	14.66	14.66	Paved	Sound
Rwanda	RN3_R	14.66	28.44	13.78	Paved	Severe
Rwanda	RN3_R	28.44	168.13	139.69	Paved	Severe
Rwanda	RN4_R	0.00	82.68	82.68	Paved	Sound
Rwanda	RN4_R	82.68	97.37	14.69	Paved	Sound
Rwanda	RN4_R	97.37	149.24	51.87	Paved	Sound
Rwanda	RN6_R	0.00	0.26	0.26	Paved	Sound
Rwanda	RN6_R	0.26	26.50	26.25	Paved	Sound
Rwanda	RN6_R	26.50	64.24	37.74	Paved	Warning
Rwanda	RN6_R	64.24	148.61	84.37	Paved	Warning
Rwanda	RN9_R	0.00	30.84	30.84	Paved	Sound
Tanzania	R107_T	0.00	8.89	8.89	Paved	Sound
Tanzania	R107-_T	0.00	54.47	54.47	Paved	Sound
Tanzania	R108_T	0.00	1.68	1.68	Paved	Sound
Tanzania	R294_T	0.00	30.42	30.42	Unpaved	Gravel
Tanzania	R561_T	0.00	54.13	54.13	Unpaved	Gravel
Tanzania	R712_T	0.00	77.15	77.15	Unpaved	Gravel
Tanzania	R827_T	0.00	70.04	70.04	Paved	Sound
Tanzania	R827_T	70.04	126.83	56.79	Unpaved	Gravel
Tanzania	T1_T	0.00	24.62	24.62	Paved	Sound
Tanzania	T1_T	24.62	25.78	1.16	Paved	Sound
Tanzania	T1_T	25.78	27.52	1.74	Paved	Sound
Tanzania	T1_T	27.93	37.66	9.72	Paved	Sound
Tanzania	T1_T	37.66	49.85	12.20	Paved	Under Construction
Tanzania	T1_T	49.86	101.08	51.23	Paved	Sound
Tanzania	T1_T	101.08	102.11	1.03	Paved	Sound
Tanzania	T1_T	102.11	186.57	84.46	Paved	Sound
Tanzania	T1_T	186.57	406.69	220.12	Paved	Sound
Tanzania	T1_T	406.69	843.62	436.93	Paved	Sound
Tanzania	T1_T	843.62	952.98	109.37	Paved	Sound
Tanzania	T13_T	0.00	76.49	76.49	Paved	Severe
Tanzania	T13_T	76.49	140.49	64.00	Unpaved	Gravel
Tanzania	T14_T	0.00	15.88	15.88	Paved	Under Construction
Tanzania	T14_T	15.88	156.25	140.37	Unpaved	Under Construction
Tanzania	T15_T	0.00	15.52	15.52	Paved	Sound

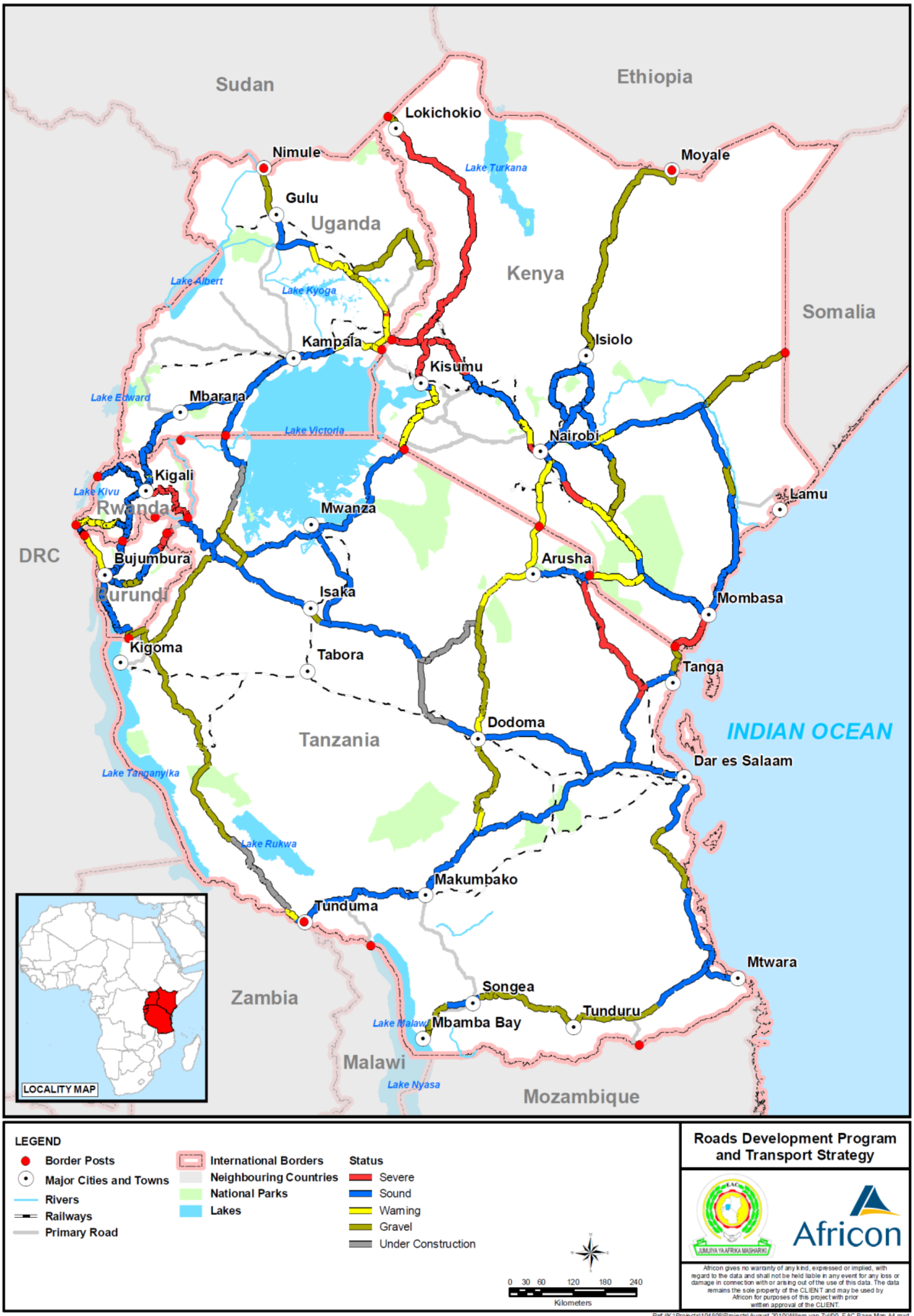
Country	Road	From (km)	To (km)	Length (km)	Type	Status
Tanzania	T2_T	0.00	170.13	170.13	Paved	Sound
Tanzania	T2_T	170.13	279.26	109.14	Paved	Severe
Tanzania	T2_T	279.26	338.91	59.64	Paved	Severe
Tanzania	T2_T	338.91	426.09	87.19	Paved	Severe
Tanzania	T2_T	426.09	528.97	102.87	Paved	Severe
Tanzania	T2_T	528.97	531.95	2.99	Paved	Sound
Tanzania	T2_T	531.95	624.59	92.64	Paved	Warning
Tanzania	T3/1_T	0.00	14.94	14.94	Paved	Sound
Tanzania	T3_T	0.00	259.37	259.37	Paved	Sound
Tanzania	T3_T	259.37	343.65	84.28	Paved	Sound
Tanzania	T3_T	343.65	375.78	32.13	Paved	Under Construction
Tanzania	T3_T	375.78	484.71	108.94	Paved	Sound
Tanzania	T3_T	484.71	704.97	220.26	Paved	Sound
Tanzania	T3_T	704.97	759.58	54.60	Unpaved	Gravel
Tanzania	T3_T	759.58	788.41	28.84	Paved	Sound
Tanzania	T3_T	788.41	981.97	193.56	Paved	Sound
Tanzania	T3_T	981.97	1107.13	125.16	Paved	Sound
Tanzania	T4_T	0.00	79.71	79.71	Paved	Sound
Tanzania	T4_T	79.71	279.01	199.29	Paved	Sound
Tanzania	T4_T	279.01	319.53	40.52	Paved	Sound
Tanzania	T4_T	319.53	476.14	156.61	Paved	Sound
Tanzania	T4_T	476.14	477.54	1.40	Unpaved	Sound
Tanzania	T4_T	477.54	525.59	48.05	Unpaved	Gravel
Tanzania	T4_T	525.59	544.43	18.84	Unpaved	Gravel
Tanzania	T4_T	544.43	545.43	1.00	Unpaved	Under Construction
Tanzania	T4_T	545.43	633.22	87.78	Unpaved	Under Construction
Tanzania	T4_T	633.22	686.71	53.49	Paved	Under Construction
Tanzania	T4_T	686.71	717.41	30.70	Paved	Sound
Tanzania	T5_T	0.00	45.03	45.03	Paved	Warning
Tanzania	T5_T	45.03	227.50	182.47	Unpaved	Gravel
Tanzania	T5_T	227.50	238.10	10.59	Paved	Sound
Tanzania	T5_T	238.10	287.64	49.54	Paved	Warning
Tanzania	T5_T	287.64	454.58	166.94	Unpaved	Gravel
Tanzania	T5_T	454.58	522.17	67.60	Unpaved	Gravel
Tanzania	T5_T	522.17	625.59	103.42	Paved	Warning
Tanzania	T5_T	625.59	648.29	22.70	Paved	Warning
Tanzania	T6_T	0.00	69.32	69.32	Paved	Sound
Tanzania	T6_T	69.32	102.06	32.74	Paved	Sound

Country	Road	From (km)	To (km)	Length (km)	Type	Status
Tanzania	T6_T	102.06	188.71	86.65	Paved	Sound
Tanzania	T6_T	188.71	320.17	131.46	Unpaved	Gravel
Tanzania	T6_T	320.17	349.27	29.10	Unpaved	Gravel
Tanzania	T6_T	349.27	487.16	137.89	Unpaved	Gravel
Tanzania	T6_T	487.16	564.01	76.84	Unpaved	Gravel
Tanzania	T6_T	564.01	646.65	82.65	Unpaved	Gravel
Tanzania	T8_T	0.00	16.44	16.44	Unpaved	Gravel
Tanzania	T8_T	16.44	17.40	0.96	Unpaved	Gravel
Tanzania	T8_T	18.36	236.37	218.01	Paved	Sound
Tanzania	T8_T	236.37	237.39	1.03	Paved	Sound
Tanzania	T8_T	237.39	365.26	127.87	Paved	Sound
Tanzania	T8_T	365.26	446.62	81.35	Paved	Gravel
Tanzania	T8_T	446.62	640.95	194.33	Paved	Sound
Tanzania	T8-1_T	0.98	39.00	38.02	Paved	Sound
Tanzania	T9_T	0.00	48.73	48.73	Paved	Warning
Tanzania	T9_T	48.73	106.60	57.87	Paved	Under Construction
Tanzania	T9_T	106.60	115.06	8.46	Unpaved	Under Construction
Tanzania	T9_T	115.06	188.55	73.49	Paved	Under Construction
Tanzania	T9_T	188.55	641.53	452.98	Unpaved	Gravel
Tanzania	T9_T	641.53	777.02	135.49	Unpaved	Gravel
Tanzania	T9_T	777.02	864.76	87.74	Unpaved	Gravel
Tanzania	T9_T	864.76	876.84	12.09	Unpaved	Gravel
Tanzania	T9_T	876.85	936.87	60.03	Unpaved	Gravel
Uganda	A001_U	0.00	134.97	134.97	Paved	Warning
Uganda	A001_U	134.97	221.35	86.38	Paved	Sound
Uganda	A001N2_U	0.00	11.86	11.86	Paved	Sound
Uganda	A002_U	0.00	35.31	35.31	Paved	Sound
Uganda	A002_U	35.31	109.24	73.94	Paved	Sound
Uganda	A002_U	109.24	111.67	2.42	Unpaved	Gravel
Uganda	A002_U	111.67	418.65	306.99	Paved	Sound
Uganda	A004_U	0.00	83.79	83.79	Paved	Sound
Uganda	A006_U	0.00	58.82	58.82	Paved	Sound
Uganda	A006_U	58.82	166.49	107.67	Unpaved	Gravel
Uganda	A007_U	0.00	70.86	70.86	Paved	Sound
Uganda	A007_U	70.86	343.27	272.41	Paved	Warning
Uganda	A007N1_U	0.00	0.79	0.79	Paved	Severe
Uganda	B300_U	0.00	77.24	77.24	Unpaved	Gravel
Uganda	B303_U	0.00	8.00	8.00	Paved	Warning

Country	Road	From (km)	To (km)	Length (km)	Type	Status
Uganda	B303_U	8.00	89.86	81.86	Unpaved	Gravel
Uganda	B303_U	89.86	169.56	79.70	Unpaved	Gravel
Uganda	B308_U	0.00	15.70	15.70	Paved	Sound
Uganda	C961_U	0.00	30.73	30.73	Unpaved	Gravel

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.



Map 6-1: Condition Status in 2010

6.3 The Needs Analysis

6.3.1 Pavement Performance Models Used for Paved Roads

In order to predict the road deterioration, reliable pavement performance prediction models are required. The models used in the Africon's dTIMS TM CT decision support software are calibrated versions of the HDM-4 pavement performance models.

These models are the most comprehensive set of pavement deterioration relationships currently available. They were derived from a broad empirical base, they are versatile, and can be adapted to local conditions with relatively little effort. The HDM-4 models attempt to model the complex interaction between vehicles, the environment and the pavement structure and surface. Pavement performance is principally a function of the combined effects of traffic and weather. Traffic loads induce stresses and strains within the pavement layers. The magnitude of these responses depends on the load characteristics and the layer thickness and stiffness. Under repeated loads these stresses and strains cause fatigue in bound materials and deformation of all pavement layers. Weathering and solar radiation causes asphaltic materials to age, become brittle, and to be more susceptible to cracking and disintegration. Once cracking has been initiated, it increases in both intensity and severity, and eventually potholes are formed. Furthermore, open cracks allow surface water to infiltrate the pavement layers hastening the process of disintegration, reducing the shear strength of the bound materials, and thus increasing the rate of deformation under traffic. The cumulative deformation under wheel loads manifests in wheelpath rutting. This, in effect, increases the pavement roughness, which in turn is further increased by weather and seasonal changes. Pavement roughness, the main indicator of pavement service, is therefore the result of a chain of distress mechanisms and the combination of various modes of distresses. This complex interaction between various distress types and the environment is reflected in the pavement performance models used in HDM-4.

In HDM-4, pavement performance models have been derived for five modes of distress. See Table 6-3 and Figure 6-4 for the distresses modelled by HDM-4 and their interaction.

Table 6-3: Flexible pavements' Distresses modelled by HDM-4

Distress Type	Description
All Cracking	The area of cracking greater than 1 mm in width, as a percentage of the total carriageway area.
Wide Cracking	The area of cracking greater than 3 mm in width, as a percentage of the total carriageway area.
Ravelling	The total area ravelled as a percentage of the total carriageway.
Potholing	The total area of open potholes (minimum depth of 25 mm and diameter of 150 mm) as a percentage of the total carriageway.
Rutting	The mean and standard deviation of rut depth as measured in mm under a 1.2 m straightedge.
Road Roughness	Roughness in IRI (International Roughness Index)

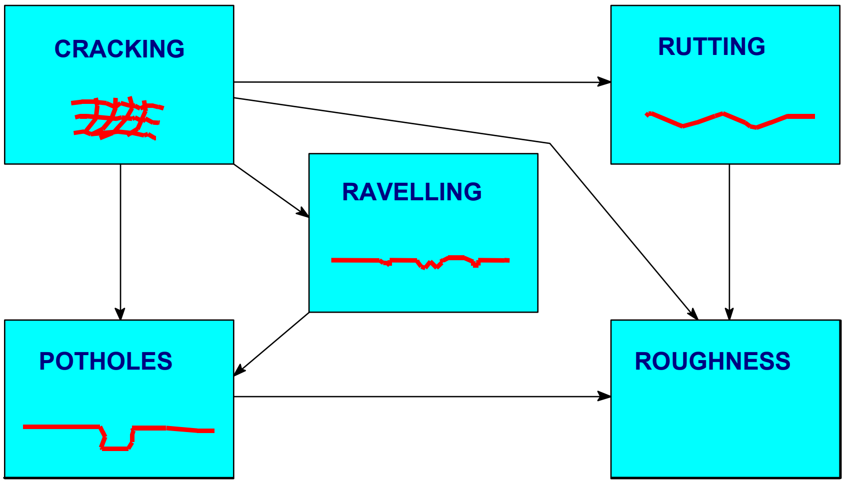


Figure 6-4: Interaction of the distress types of flexible paved roads as modelled in HDM-4

In order to use the HDM-4 performance prediction models, the available visual assessment and roughness data were converted to the HDM distress types.

6.3.2 Methodology

The needs analysis of the EAC corridor entails the prediction of the technical needs of the road network over the next 10 years, using the current condition as the departure point of pavement deterioration and using the pavement performance models of HDM-4 to predict the pavement deterioration.

6.3.2.1 Paved roads

In this analysis, a rehabilitation repair action (intervention treatment) was triggered for a paved road once its overall condition has deteriorated beyond the point where preventive and routine maintenance can uphold the pavement at a functional level. The deterioration of paved roads is based on the pavement performance models of HDM-4. For maintenance, the premise is on keeping the EAC road corridor preventively maintained; a world–wide accepted sound infrastructure asset management principle. This study assumes the preservation of paved roads includes preventive maintenance and sound routine maintenance practices associated with multi-national road infrastructure. Preventive maintenance includes reseals and fogspray to prevent the ingress of water through cracks in the surface layers. It also prevents the surfacing from disintegration, becoming dry and brittle and subject to cracking. There will always be a minimum need for routine maintenance (on and off the road surfaces), even when paved roads are maintained at optimum levels. Activities such as pothole repair and pothole patching, edge break repair, crack filling, bush clearing, etc are included. Road networks deteriorate at increased rates if routine maintenance is neglected.

6.3.2.2 Gravel roads

For gravel roads the alternative to ‘upgrade to paved standards’ was the only alternative considered. The EAC road corridor identified by this study feeds the current and future economic development in the five countries, both locally and across borders. Gravel roads with traffic volumes in excess of 200 vehicles per day operate under poor riding quality conditions and generate excessive costs to road users as well as escalating routine maintenance costs to the road authorities. The 'upgrade to paved standards' option is the alternative that yields the highest economic benefit. A high level of traffic on any gravel road is an indication of potential growth, but economic growth will not be stimulated in areas dependant on gravel road infrastructure. Economic development and growth cannot reach their full potential if the road network serving it, has gravel roads. A total paved road network is therefore in agreement with the objectives of the EAC corridors. The methodology behind the Upgrading Programme of existing gravel roads is a phased programme spread over the first five years, namely 2011 to 2015.

6.3.3 Unit Prices

The unit prices assumed were based on findings of a recent study conducted on Unit Costs and Cost Overruns of Road Infrastructure Projects in Africa whereby an analysis was performed on a total of 173 projects (sourced from the 2008 AICD study, the 2007 AfDB study and new projects identified during a 2010 site visit to the AfDB in Tunis), to determine unit rates for different types of road infrastructure investments. Table 6-4 provides a summary of the findings of the said study. The unit rates are presented as median (not average) rates, bounded by first and third quartile intervals. One set of statistics is provided for projects smaller than 100 lane km (typically subject to a large variance) and those larger than 100 lane km (typically demonstrating fairly small variance).

Table 6-4: Summary of Unit Rate statistics for Different Types of Road Infrastructure Investment (USD/Lane km, rounded to '00)

Type of Road Infrastructure Investment	Re-graveling/ Periodic Maintenance of Unpaved Roads	Periodic Maintenance of Paved Roads	Rehabilitation of Paved Roads	Construction and Upgrading of Paved Roads
< 100 lane km				
Quartile 3	10 500	N/A	290 000	425 400
Median	9 600	N/A	180 300	227 800
Quartile 1	8 100	N/A	109 800	166 300
≥ 100 lane km				
Quartile 3	12 800	72 200	130 500	162 000
Median	11 300	64 600	84 400	147 100
Quartile 1	9 600	56 900	47 400	115 900

Source: Study conducted by Aurecon entitled: 'Road Infrastructure Costs in Africa: Analyse Unit Costs and Cost Overruns of Road Infrastructure Projects in Africa' - 2011

Note: All values are given in 2006 USD/ lane km

Based on the findings of the abovementioned study, and on Table 6-4 above, the following Unit Prices were assumed for this study (note that these unit prices were derived from the upper quartile / limit referring to Table 6-4):

- **USD100** per square meter for the rehabilitation of paved roads.
- **USD120** per square meter to upgrade an existing gravel road to paved standards.

6.3.4 Road Sections

Road sections with similar characteristics and condition were analysed together to determine their future need for rehabilitation and upgrading. In order to present a feasible Rehabilitation and Upgrading (R&U) Plan, the results of the analysis were used to further combine the analysed road sections into larger road sections. The R&U Plan therefore contains practical road lengths that can be used for the planning of viable future road projects.

6.3.5 Scenario Analysis

The data set obtained through the procedures described in the previous chapters serves as input to the analysis of technical needs for various planning scenarios.

The following section provides the results of the base scenario analysis, where future traffic growth is not affected by possible future changes in modal transportation across the EAC region. That means that the traffic growth over the ten year planning period is based on historic traffic growth projected over the ten year planning period excluding possible future modal changes in transportation between road/rail/air/sea/lake transportation.

Note that the only variable in the scenario analysis is the traffic volume changes across scenarios. They all have the same corridor road conditions as first year base, and traffic volume changes are as a result of estimated changes in the modal transportation split over the ten year planning horizon between the various transportation modes investigated in this study. The scenario analyses are thus re-active – expected future traffic volumes generated as a result of foreseen future events (e.g. opening of a new mine, gas field, expected change in mode of transportation from road to rail, etc) result in different future road deterioration for the roads affected and thus technical needs than for the base scenario.

6.4 Technical Needs (Results of the LCCA – Base Scenario)

The results of the life cycle cost analysis (LCCA) are presented in Table 6-5 and Table 6-6, and summarised per corridor in the following Sections, with Map 6-2 spatially representing such results below. The annual technical needs with regards to cost and road length are presented, as well as the proposed Rehabilitation and Upgrading Plan.

Table 6-5: Technical Needs – Base Scenario - Cost (USD)

	Rehabilitation	Upgrade to Pave	Total
2011	1,068,898,614	684,046,422	1,752,945,036
2012	313,476,080	728,683,172	1,042,159,252
2013	474,741,426	451,788,946	926,530,372
2014	400,715,693	776,792,513	1,177,508,206
2015	894,081,323	512,034,579	1,406,115,903
2016	154,795,196	-	154,795,196
2017	494,988,213	-	494,988,213
2018	475,900,607	-	475,900,607

	Rehabilitation	Upgrade to Pave	Total
2019	19,263,999	-	19,263,999
2020	326,034,821	-	326,034,821
Average: 2011 to 2015	630,382,627	630,669,126	1,261,051,754
Average: 2016 to 2020	294,196,567	-	294,196,567

Source: Africon, 2010

Table 6-6: Technical Needs – base scenario - length (km)

	Rehabilitation	Upgrade to Pave	Total
2011	1,527	814.34	2,341
2012	447.82	867.48	1,315
2013	678.20	537.84	1,216
2014	572.45	924.75	1,497
2015	1,277	609.56	1,887
2016	221.14	-	221
2017	707.13	-	707
2018	679.86	-	680
2019	27.52	-	28
2020	465.76	-	466
Average: 2011 to 2015	901	751	1,651
Average: 2016 to 2020	420	-	420

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-7: Technical Needs Results - Arusha Corridor

Unit cost rehabilitation (USD) per square meter:									100
Unit cost upgrading to paved standards (USD) per square meter:									120
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Tanzania	R294_T	0.00	30.42	30.42	Unpaved	Gravel	Upgrade to Pave	2015	25,551,961
Tanzania	T2_T	170.13	279.26	109.14	Paved	Severe	Rehabilitation	2011	76,394,500
Tanzania	T2_T	279.26	338.91	59.64	Paved	Severe	Rehabilitation	2011	41,750,809
Tanzania	T2_T	338.91	426.09	87.19	Paved	Severe	Rehabilitation	2011	61,029,507

Unit cost rehabilitation (USD) per square meter:									100
Unit cost upgrading to paved standards (USD) per square meter:									120
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Tanzania	T2_T	426.09	528.97	102.87	Paved	Severe	Do Nothing		
Tanzania	T2_T	528.97	531.95	2.99	Paved	Sound	Rehabilitation	2012	2,091,602
Tanzania	T5_T	625.59	648.29	22.70	Paved	Warning	Rehabilitation	2013	15,890,704

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-8: Technical Needs Results - Central Corridor

Unit cost rehabilitation (USD) per square meter:									100
Unit cost upgrading to paved standards (USD) per square meter:									120
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Burundi	RN1_B	0.00	7.09	7.09	Paved	Sound	Do Nothing		
Burundi	RN1_B	7.09	113.68	106.59	Paved	Sound	Rehabilitation	2017	74,613,701
Burundi	RN1_N1_B	0.00	0.44	0.44	Paved	Sound	Do Nothing		
Burundi	RN1_N2_B	0.00	0.10	0.10	Paved	Sound	Do Nothing		
Burundi	RN1_N3_B	0.00	0.14	0.14	Paved	Sound	Do Nothing		
Burundi	RN12_B	0.00	1.68	1.68	Paved	Sound	Do Nothing		
Burundi	RN12_B	1.68	94.00	92.32	Unpaved	Gravel	Upgrade to Pave	2011	77,550,478
Burundi	RN16_B	0.00	6.00	6.00	Unpaved	Gravel	Upgrade to Pave	2012	5,038,320
Burundi	RN18_B	0.00	48.71	48.71	Unpaved	Gravel	Upgrade to Pave	2012	40,914,720
Burundi	RN3_B	0.00	0.70	0.70	Paved	Sound	Do Nothing		
Burundi	RN5_B	0.00	77.11	77.11	Paved	Warning	Rehabilitation	2012	53,974,902
Burundi	RN5_B	77.11	84.24	7.13	Paved	Sound	Do Nothing		
Burundi	RN5_N_B	0.00	0.31	0.31	Paved	Sound	Do Nothing		
Burundi	RN6_B	0.00	1.31	1.31	Unpaved	Gravel	Upgrade to Pave	2011	1,097,880
Burundi	RN6_B	1.31	28.43	27.12	Paved	Severe	Rehabilitation	2011	18,987,499
Burundi	RN7_B	0.00	48.04	48.04	Paved	Sound	Rehabilitation	2018	33,628,700
Burundi	RN8_B	0.00	4.92	4.92	Paved	Sound	Do Nothing		
Rwanda	RN1_R	0.00	0.26	0.26	Paved	Sound	Do Nothing		
Rwanda	RN1_R	0.28	2.49	2.21	Paved	Sound	Do Nothing		
Rwanda	RN1_R	2.49	2.70	0.21	Paved	Sound	Do Nothing		
Rwanda	RN1_R	2.70	21.42	18.72	Paved	Sound	Do Nothing		
Rwanda	RN1_R	21.43	155.07	133.64	Paved	Sound	Do Nothing		
Rwanda	RN12_R	0.00	4.84	4.84	Paved	Sound	Do Nothing		
Rwanda	RN3_N_R	0.00	0.23	0.23	Paved	Sound	Do Nothing		
Rwanda	RN3_R	0.00	14.66	14.66	Paved	Sound	Do Nothing		
Rwanda	RN3_R	14.66	28.44	13.78	Paved	Severe	Rehabilitation	2011	9,644,599
Rwanda	RN3_R	28.44	168.13	139.69	Paved	Severe	Rehabilitation	2012	97,785,797
Rwanda	RN4_R	0.00	82.68	82.68	Paved	Sound	Rehabilitation	2015	57,877,399
Rwanda	RN4_R	82.68	97.37	14.69	Paved	Sound	Rehabilitation	2015	10,283,701
Rwanda	RN4_R	97.37	149.24	51.87	Paved	Sound	Do Nothing		

Unit cost rehabilitation (USD) per square meter:								100	
Unit cost upgrading to paved standards (USD) per square meter:								120	
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Rwanda	RN6_R	0.26	26.50	26.25	Paved	Sound	Rehabilitation	2015	18,371,501
Rwanda	RN6_R	26.50	64.24	37.74	Paved	Warning	Rehabilitation	2013	26,418,697
Rwanda	RN6_R	64.24	148.61	84.37	Paved	Warning	Rehabilitation	2011	59,058,300
Rwanda	RN9_R	0.00	30.84	30.84	Paved	Sound	Do Nothing		
Tanzania	R107_T	0.00	8.89	8.89	Paved	Sound	Do Nothing		
Tanzania	R107-_T	0.00	54.47	54.47	Paved	Sound	Do Nothing		
Tanzania	R108_T	0.00	1.68	1.68	Paved	Sound	Do Nothing		
Tanzania	T1_T	0.00	24.62	24.62	Paved	Sound	Rehabilitation	2019	17,231,199
Tanzania	T1_T	24.62	25.78	1.16	Paved	Sound	Rehabilitation	2019	814,100
Tanzania	T1_T	25.78	27.52	1.74	Paved	Sound	Rehabilitation	2019	1,218,700
Tanzania	T1_T	27.93	37.66	9.72	Paved	Sound	Do Nothing		
Tanzania	T1_T	37.66	49.85	12.20	Paved	Under Construction	Do Nothing		
Tanzania	T1_T	49.86	101.08	51.23	Paved	Sound	Do Nothing		
Tanzania	T1_T	102.11	186.57	84.46	Paved	Sound	Do Nothing		
Tanzania	T3/1_T	0.00	14.94	14.94	Paved	Sound	Do Nothing		
Tanzania	T3_T	0.00	259.37	259.37	Paved	Sound	Do Nothing		
Tanzania	T3_T	259.37	343.65	84.28	Paved	Sound	Do Nothing		
Tanzania	T3_T	343.65	375.78	32.13	Paved	Under Construction	Do Nothing		
Tanzania	T3_T	375.78	484.71	108.94	Paved	Sound	Do Nothing		
Tanzania	T3_T	484.71	704.97	220.26	Paved	Sound	Do Nothing		
Tanzania	T3_T	704.97	759.58	54.60	Unpaved	Gravel	Upgrade to Pave	2011	45,865,690
Tanzania	T3_T	759.58	788.41	28.84	Paved	Sound	Rehabilitation	2020	20,187,301
Tanzania	T3_T	788.41	981.97	193.56	Paved	Sound	Do Nothing		
Tanzania	T3_T	981.97	1107.13	125.16	Paved	Sound	Do Nothing		
Tanzania	T4_T	279.01	319.53	40.52	Paved	Sound	Rehabilitation	2018	28,363,306
Tanzania	T4_T	545.43	633.22	87.78	Unpaved	Under Construction	Do Nothing		
Tanzania	T4_T	633.22	686.71	53.49	Paved	Under Construction	Do Nothing		
Tanzania	T4_T	686.71	717.41	30.70	Paved	Sound	Do Nothing		
Tanzania	T8_T	16.44	17.40	0.96	Unpaved	Gravel	Upgrade to Pave	2011	804,719
Tanzania	T8_T	18.36	236.37	218.01	Paved	Sound	Do Nothing		
Tanzania	T8_T	236.37	237.39	1.03	Paved	Sound	Do Nothing		
Tanzania	T9_T	876.85	936.87	60.03	Unpaved	Gravel	Upgrade to Pave	2015	50,423,508
Uganda	A004_U	0.00	83.79	83.79	Paved	Sound	Do Nothing		
Tanzania	Road1_T	0.00	23.65	23.65	Unpaved	Gravel	Upgrade to Pave	2012	19,861,800
Tanzania	Road3A_T	0.00	2.12	2.12	Unpaved	Gravel	Upgrade to Pave	2011	1,780,800

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-9: Technical Needs Results - Coastal Corridor

Unit cost rehabilitation (USD) per square meter:									100
Unit cost upgrading to paved standards (USD) per square meter:									120
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Kenya	A14_K	0.00	106.43	106.43	Paved	Severe	Rehabilitation	2011	74,501,000
Kenya	B8_K	202.93	353.64	150.71	Paved	Sound	Rehabilitation	2015	105,497,710
Kenya	B8_K	353.64	448.76	95.12	Paved	Sound	Rehabilitation	2015	66,582,597
Tanzania	R712_T	0.00	77.15	77.15	Unpaved	Gravel	Upgrade to Pave	2012	64,810,199
Tanzania	T1_T	0.00	24.62	24.62	Paved	Sound	Rehabilitation	2019	17,231,199
Tanzania	T1_T	24.62	25.78	1.16	Paved	Sound	Rehabilitation	2019	814,100
Tanzania	T1_T	25.78	27.52	1.74	Paved	Sound	Rehabilitation	2019	1,218,700
Tanzania	T1_T	27.93	37.66	9.72	Paved	Sound	Do Nothing		
Tanzania	T1_T	37.66	49.85	12.20	Paved	Under Construction	Do Nothing		
Tanzania	T1_T	49.86	101.08	51.23	Paved	Sound	Do Nothing		
Tanzania	T13_T	0.00	76.49	76.49	Paved	Severe	Do Nothing		
Tanzania	T13_T	76.49	140.49	64.00	Unpaved	Gravel	Upgrade to Pave	2011	53,758,321
Tanzania	T2_T	0.00	170.13	170.13	Paved	Sound	Rehabilitation	2018	119,089,604
Tanzania	T6_T	0.00	69.32	69.32	Paved	Sound	Rehabilitation	2017	48,526,798
Tanzania	T8_T	237.39	365.26	127.87	Paved	Sound	Do Nothing		
Tanzania	T8_T	365.26	446.62	81.35	Paved	Gravel	Upgrade to Pave	2011	68,337,370
Tanzania	T8_T	446.62	640.95	194.33	Paved	Sound	Do Nothing		

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-10: Technical Needs Results - Gulu Corridor

Unit cost rehabilitation (USD) per square meter:									100
Unit cost upgrading to paved standards (USD) per square meter:									120
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Uganda	A006_U	0.00	58.82	58.82	Paved	Sound	Rehabilitation	2018	41,176,101
Uganda	A006_U	58.82	166.49	107.67	Unpaved	Gravel	Upgrade to Pave	2011	90,443,643
Uganda	A007_U	0.00	70.86	70.86	Paved	Sound	Rehabilitation	2014	49,598,502
Uganda	A007_U	70.86	343.27	272.41	Paved	Warning	Rehabilitation	2013	190,689,104
Uganda	A007N1_U	0.00	0.79	0.79	Paved	Severe	Rehabilitation	2013	552,300

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-11: Technical Needs Results - Mtwara Corridor

Unit cost rehabilitation (USD) per square meter:									**100**
Unit cost upgrading to paved standards (USD) per square meter:									**120**
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Tanzania	R827_T	0.00	70.04	70.04	Paved	Sound	Do Nothing		
Tanzania	R827_T	70.04	126.83	56.79	Unpaved	Gravel	Upgrade to Pave	2014	47,706,122
Tanzania	T6_T	0.00	69.32	69.32	Paved	Sound	Rehabilitation	2017	48,526,798
Tanzania	T6_T	69.32	102.06	32.74	Paved	Sound	Rehabilitation	2017	22,915,198
Tanzania	T6_T	102.06	188.71	86.65	Paved	Sound	Rehabilitation	2016	60,654,300
Tanzania	T6_T	188.71	320.17	131.46	Unpaved	Gravel	Upgrade to Pave	2015	110,427,251
Tanzania	T6_T	320.17	349.27	29.10	Unpaved	Gravel	Upgrade to Pave	2014	24,444,837
Tanzania	T6_T	349.27	487.16	137.89	Unpaved	Gravel	Upgrade to Pave	2012	115,828,429
Tanzania	T6_T	487.16	564.01	76.84	Unpaved	Gravel	Upgrade to Pave	2014	64,548,944
Tanzania	T6_T	564.01	646.65	82.65	Unpaved	Gravel	Upgrade to Pave	2012	69,424,313

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-12: Technical Needs Results - Namanga Corridor

Unit cost rehabilitation (USD) per square meter:									**100**
Unit cost upgrading to paved standards (USD) per square meter:									**120**
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Kenya	A104_K	403.30	463.04	59.74	Paved	Severe	Rehabilitation	2011	41,814,503
Kenya	A104_K	463.04	599.73	136.70	Paved	Warning	Rehabilitation	2011	95,687,896
Kenya	A2_K	0.00	83.01	83.01	Paved	Sound	Rehabilitation	2015	58,104,903
Kenya	A2_K	83.01	285.32	202.31	Paved	Sound	Rehabilitation	2017	141,619,105
Kenya	A2_K	285.32	772.34	487.02	Unpaved	Gravel	Upgrade to Pave	2014	409,093,439
Kenya	A2_N_K	0.00	31.06	31.06	Paved	Sound	Rehabilitation	2017	21,738,500
Tanzania	T2_T	531.95	624.59	92.64	Paved	Warning	Rehabilitation	2012	64,849,379
Tanzania	T2_T	609.06	634.57	25.51	Paved	Warning	Rehabilitation	2012	17,859,800
Tanzania	T5_T	0.00	45.03	45.03	Paved	Warning	Rehabilitation	2016	31,520,999
Tanzania	T5_T	45.03	227.50	182.47	Unpaved	Gravel	Upgrade to Pave	2014	153,276,479
Tanzania	T5_T	227.50	238.10	10.59	Paved	Sound	Rehabilitation	2013	7,415,101
Tanzania	T5_T	238.10	287.64	49.54	Paved	Warning	Rehabilitation	2013	34,680,805
Tanzania	T5_T	287.64	454.58	166.94	Unpaved	Gravel	Upgrade to Pave	2015	140,227,917
Tanzania	T5_T	454.58	522.17	67.60	Unpaved	Gravel	Upgrade to Pave	2011	56,780,618
Tanzania	T5_T	522.17	625.59	103.42	Paved	Warning	Rehabilitation	2013	72,394,012
Tanzania	T5_T	625.59	648.29	22.70	Paved	Warning	Rehabilitation	2013	15,890,704

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-13: Technical Needs Results - Northern Corridor

Unit cost rehabilitation (USD) per square meter:									100
Unit cost upgrading to paved standards (USD) per square meter:									120
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Kenya	A104_K	Malaba	Webuye	57.20	Paved	Severe	Rehabilitation	2015	40,040,000
Kenya	A104_K	Webuye	Eldoret	57.69	Paved	Severe	Rehabilitation	2015	40,379,501
Kenya	A104_K	Webuye	Eldoret	12.22	Paved	Severe	Rehabilitation	2015	8,550,500
Kenya	A104_K	Timboroa	Mau-Summit	38.70	Paved	Sound	Do Nothing		
Kenya	A104_K	Timboroa	Eldoret	64.10	Paved	Severe	Rehabilitation	2015	44,870,000
Kenya	A104_K	Mau-Summit-Njoro T'Off-Lanet-Naivasha		113.00	Paved	Sound	Do Nothing		
Kenya	A104_K	Naivasha	Limuru	59.50	Paved	Warning	Rehabilitation	2014	41,650,000
Kenya	A104_K	Limuru	Museum Hill	34.00	Paved	Severe	Rehabilitation	2011	23,800,000
Kenya	A104_K	Museum Hill-JKIA-Athi River		24.10	Paved	Sound	Do Nothing		
Kenya	A104_K	403.30	463.04	59.74	Paved	Severe	Rehabilitation	2011	41,814,503
Kenya	A109_K	0.00	9.91	9.91	Paved	Warning/ Need Reseal	Rehabilitation	2017	6,934,910
Kenya	A109_K	9.91	46.21	36.30	Paved	Sound	Do Nothing		
Kenya	A109_K	46.21	100.21	54.00	Paved	Severe	Rehabilitation	2011	37,800,000
Kenya	A109_K	100.21	249.21	149.00	Paved	Warning/ Need Reseal	Rehabilitation	2017	104,300,000
Kenya	A109_K	249.21	281.93	32.72	Paved	Sound	Do Nothing		
Kenya	A109_K	281.93	406.98	125.05	Paved	Sound	Do Nothing		
Kenya	A109_K	406.98	457.41	50.43	Paved	Sound	Do Nothing		
Kenya	C88	Naivasha	Maai Mahiu	37.00	Paved	Sound	Do Nothing		
Kenya	C88	Maai Mahiu	Rironi	19.50	Paved	Warning	Rehabilitation	2017	13,650,000
Rwanda	RN1_R	0.26	0.28	0.02	Paved	Sound	Do Nothing		
Rwanda	RN1_R	0.28	2.49	2.21	Paved	Sound	Do Nothing		
Rwanda	RN2_R	0.00	3.25	3.25	Paved	Sound	Do Nothing		
Rwanda	RN2_R	3.25	7.02	3.77	Paved	Sound	Rehabilitation	2018	2,641,800
Rwanda	RN2_R	7.02	34.92	27.90	Paved	Sound	Rehabilitation	2018	19,531,399
Rwanda	RN2_R	34.93	49.44	14.51	Paved	Warning	Rehabilitation	2015	10,159,100
Rwanda	RN2_R	49.44	77.34	27.90	Paved	Sound	Rehabilitation	2015	19,529,299
Rwanda	RN6_R	0.00	0.26	0.26	Paved	Sound	Rehabilitation	2015	179,900
Uganda	A001_U	0.00	134.97	134.97	Paved	Warning	Rehabilitation	2013	94,479,001
Uganda	A001_U	134.97	221.35	86.38	Paved	Sound	Rehabilitation	2014	60,463,195
Uganda	A001N2_U	0.00	11.86	11.86	Paved	Sound	Do Nothing		
Uganda	A002_U	0.00	35.31	35.31	Paved	Sound	Do Nothing		
Uganda	A002_U	35.31	109.24	73.94	Paved	Sound	Rehabilitation	2016	51,755,197
Uganda	A002_U	109.24	111.67	2.42	Unpaved	Gravel	Upgrade to Pave	2011	2,036,160
Uganda	A002_U	111.67	418.65	306.99	Paved	Sound	Rehabilitation	2014	214,890,894

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-14: Technical Needs Results - Sirari Corridor

Unit cost rehabilitation (USD) per square meter:								100	
Unit cost upgrading to paved standards (USD) per square meter:								120	
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Kenya	A1_K	0.00	29.10	29.10	Unpaved	Gravel	Upgrade to Pave	2011	24,444,000
Kenya	A1_K	29.10	242.10	213.00	Paved	Severe	Rehabilitation	2011	149,100,000
Kenya	A1_K	242.10	437.90	195.80	Paved	Severe	Rehabilitation	2011	137,060,000
Kenya	A1_K	437.90	538.50	100.60	Paved	Severe	Rehabilitation	2011	70,420,000
Kenya	A1_K	538.50	601.00	62.50	Paved	Severe	Rehabilitation	2011	43,750,000
Kenya	A1_K	601.00	649.00	48.00	Paved	Severe	Rehabilitation	2011	33,600,000
Kenya	A1_K	649.00	698.50	49.50	Paved	Severe	Rehabilitation	2011	34,650,000
Kenya	A1_K	698.50	722.30	23.80	Paved	Sound	Do Nothing		
Kenya	A104_K	807.80	894.50	86.70	Paved	Warning	Rehabilitation	2017	60,690,000
Tanzania	T4_T	0.00	79.71	79.71	Paved	Sound	Do Nothing		
Tanzania	T4_T	79.71	279.01	199.29	Paved	Sound	Rehabilitation	2018	139,505,797
Tanzania	T4_T	319.53	476.14	156.61	Paved	Sound	Do Nothing		
Tanzania	T4_T	476.14	477.54	1.40	Unpaved	Sound	Do Nothing		
Tanzania	T4_T	477.54	525.59	48.05	Unpaved	Gravel	Upgrade to Pave	2015	40,362,855
Tanzania	T4_T	525.59	544.43	18.84	Unpaved	Gravel	Upgrade to Pave	2011	15,823,074
Tanzania	T4_T	544.43	545.43	1.00	Unpaved	Under Construction	Do Nothing		
Tanzania	T8_T	0.00	16.44	16.44	Unpaved	Gravel	Upgrade to Pave	2011	13,812,121

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-15: Technical Needs Results - Sumbawanga Corridor

Unit cost rehabilitation (USD) per square meter:								100	
Unit cost upgrading to paved standards (USD) per square meter:								120	
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Burundi	RN3_B	0.00	0.70	0.70	Paved	Sound	Do Nothing		
Burundi	RN3_B	0.71	7.22	6.51	Paved	Sound	Do Nothing		
Burundi	RN3_B	7.22	146.60	139.38	Paved	Sound	Do Nothing		
Burundi	RN3_B	146.60	164.06	17.46	Unpaved	Gravel	Upgrade to Pave	2011	14,667,244
Tanzania	R561_T	0.00	54.13	54.13	Unpaved	Gravel	Upgrade to Pave	2013	45,470,040
Tanzania	T9_T	0.00	48.73	48.73	Paved	Warning	Rehabilitation	2014	34,113,101
Tanzania	T9_T	48.73	106.60	57.87	Paved	Under Construction	Do Nothing		
Tanzania	T9_T	106.60	115.06	8.46	Unpaved	Under Construction	Do Nothing		
Tanzania	T9_T	115.06	188.55	73.49	Paved	Under Construction	Do Nothing		
Tanzania	T9_T	188.55	641.53	452.98	Unpaved	Gravel	Upgrade to	2013	380,507,385

Unit cost rehabilitation (USD) per square meter:									100
Unit cost upgrading to paved standards (USD) per square meter:									120
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
							Pave		
Tanzania	T9_T	641.53	777.02	135.49	Unpaved	Gravel	Upgrade to Pave	2011	113,809,065
Tanzania	T9_T	777.02	864.76	87.74	Unpaved	Gravel	Upgrade to Pave	2012	73,701,577
Tanzania	T9_T	864.76	876.84	12.09	Unpaved	Gravel	Upgrade to Pave	2015	10,152,215

Source: Africon, 2010

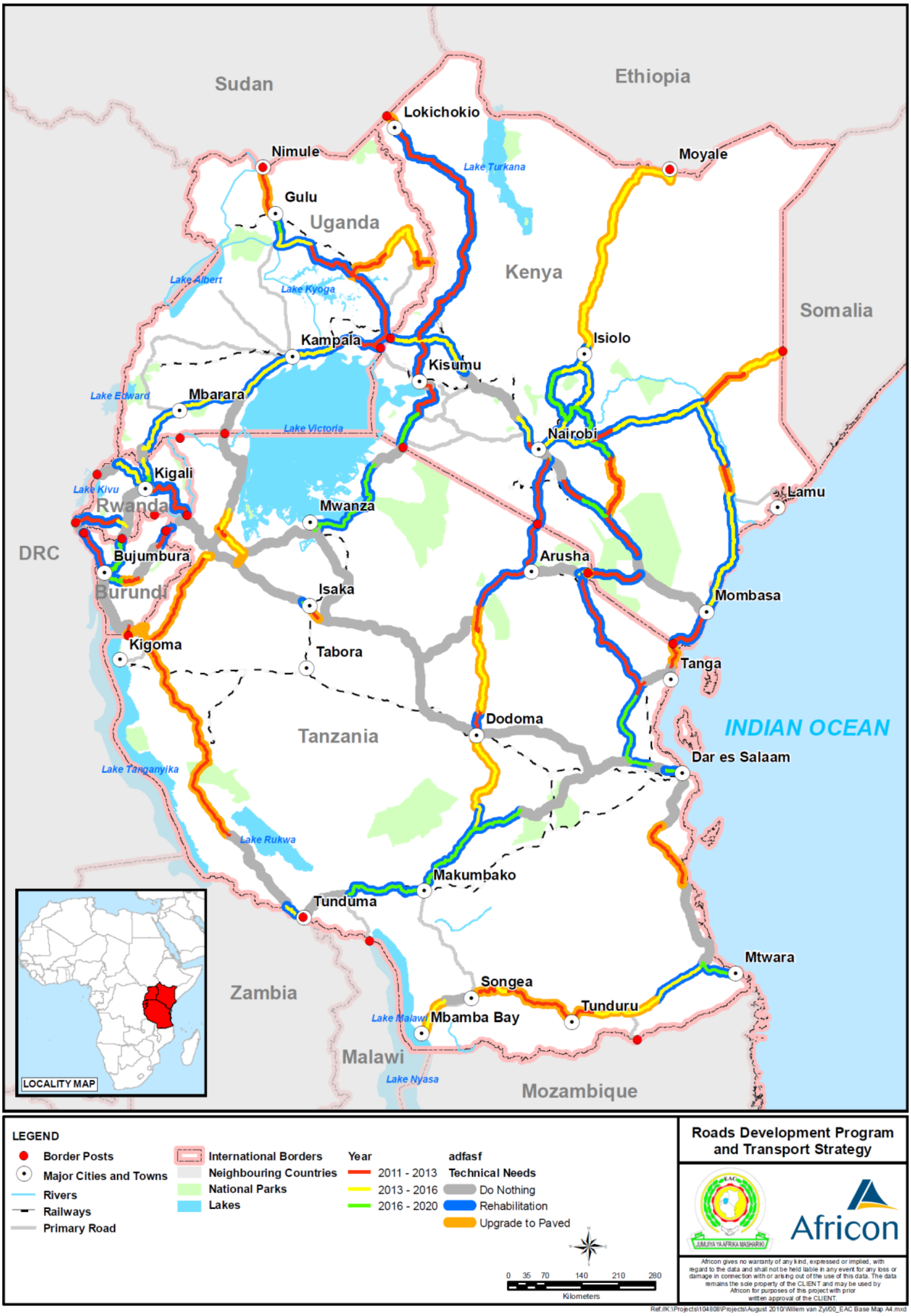
Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.

Table 6-16: Technical Needs Results - Dar es Salaam (TAZARA) Corridor

Unit cost rehabilitation (USD) per square meter:									100
Unit cost upgrading to paved standards (USD) per square meter:									120
Country	Road	From km	To km	Length	Type	Status	Technical Needs	Year	Cost USD
Tanzania	T1_T	0.00	24.62	24.62	Paved	Sound	Rehabilitation	2019	17,231,199
Tanzania	T1_T	24.62	25.78	1.16	Paved	Sound	Rehabilitation	2019	814,100
Tanzania	T1_T	25.78	27.52	1.74	Paved	Sound	Rehabilitation	2019	1,218,700
Tanzania	T1_T	27.93	37.66	9.72	Paved	Sound	Do Nothing		
Tanzania	T1_T	37.66	49.85	12.20	Paved	Under Construction	Do Nothing		
Tanzania	T1_T	49.86	101.08	51.23	Paved	Sound	Do Nothing		
Tanzania	T1_T	101.08	102.11	1.03	Paved	Sound	Do Nothing		
Tanzania	T1_T	102.11	186.57	84.46	Paved	Sound	Do Nothing		
Tanzania	T1_T	186.57	406.69	220.12	Paved	Sound	Do Nothing		
Tanzania	T1_T	406.69	843.62	436.93	Paved	Sound	Rehabilitation	2020	305,847,519
Tanzania	T1_T	843.62	952.98	109.37	Paved	Sound	Do Nothing		

Source: Africon, 2010

Note: Lengths are approximate. Lengths may differ from those used by e.g. the corridor agencies or the EAC amongst others because of duplicate sections, or the resolution of the GIS.



Map 6-2: Technical Needs – Base Scenario

7. OVERLOAD CONTROL

Road transport plays a fundamental role in the social and economic development of many developing countries. In the EAC region and in the individual member states, it provides the dominant mode of freight and passenger movements and carries between eighty and ninety percent of the region's total trade in goods and services. Thus, in order to attain acceptable levels of road transport efficiency, the management and maintenance of road infrastructure and assets form an important part of development programmes.

7.1 The Overloading Problem

In order to fully appreciate the importance of effective overload control, it is necessary to firstly be fully aware of why it is so important to control axle loads and to understand the impact and cost implications of overloading on pavements, bridges and the transport industry.

Road infrastructure represents huge investments for any country. To protect these assets against misuse and damage, individual countries have promulgated Road Traffic Acts that stipulate permissible axle load, axle group combinations and vehicle dimensions. These limits are meant to ensure that roads last for their full design life with normal maintenance expenditures. In addition, control of axle loads to prescribed limits can be justified for the following reasons:

- ensuring a level playing field between transporters
- limiting the extent of road maintenance required
- improving road safety

Laws and regulations to control overloading have been in existence in Sub Sahara African countries for more than 40 years, and have been changed and updated over years to reflect the changing circumstances of the road transport industry. During the same period the road transport vehicles have grown in size and road transport has increased with the removal of the protection of railways in some countries and the liberalisation of the economies.

A gradual but marked shift from rail to road in the 1980s became more rapid in the nineties and into the current century. Smaller trucks were substituted with today's interlinks and super-links. Axle load control and enforcement of legal loads have only in very few of the Sub Sahara African countries kept pace with this development of road transport.

7.2 Impact of Overloading

7.2.1 Pavements

Most road pavements are designed to carry a range of 'standard' (8.2 tonne) axles over a period of time. The number of 'Equivalent Standard Axles' (ESAs) is determined with respect to the type of traffic expected to use the road over its design life. The AASHO road tests that were carried out in the USA during the years 1959 – 61 established that the life of a given road is approximately proportional to the fourth power of the axle load for the same number of passes. The test resulted in the following well known formula – the Fourth Power Law - which postulates an exponential relationship between axle loads and damaging power.

$$LEF = \left(\frac{P}{W_s}\right)^n$$

Where:

LEF = load equivalence factor

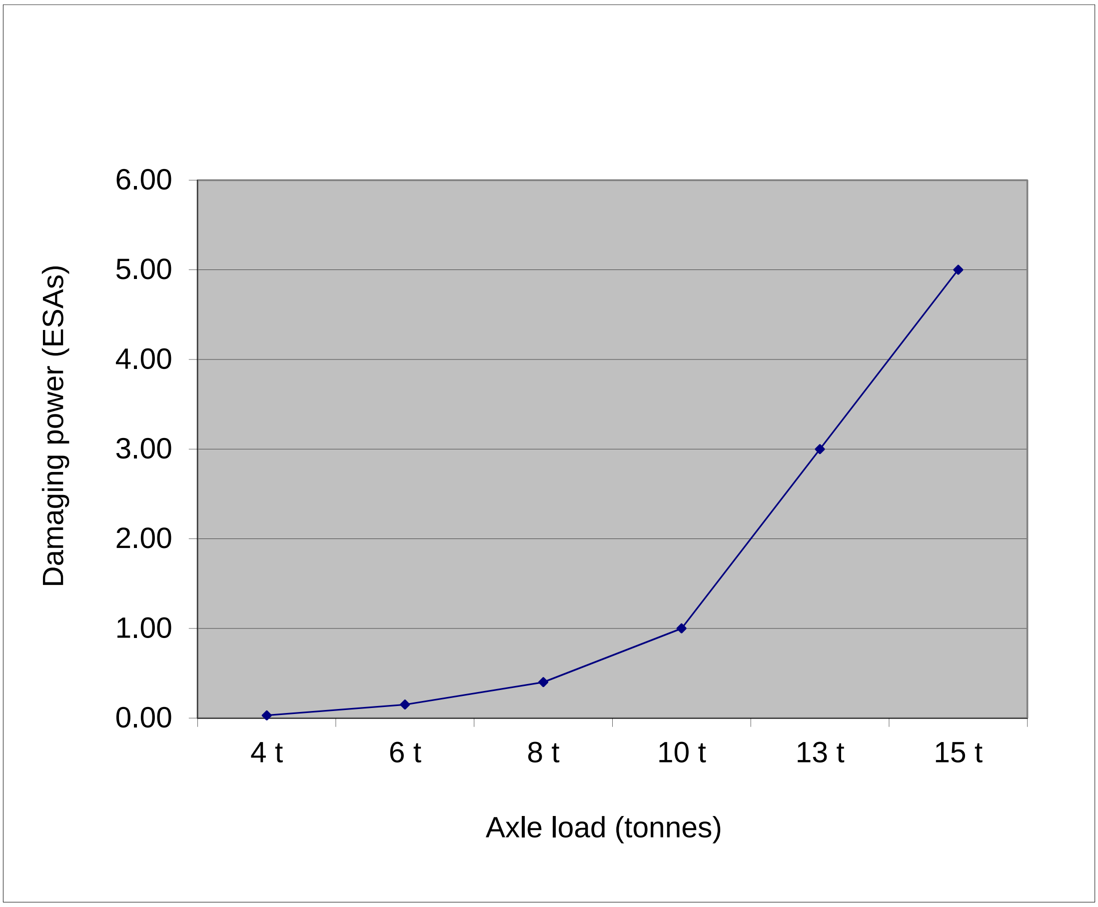
P = axle load

W_s = standard axle (8.2 or 10 tonnes)

n = power law exponent

(Typically assumed to be 4.2)

Note: Further experimental and research work under-taken since the AASHO road test has indicated that the power law exponent is related to pavement type (granular, cemented, etc. And mode of distress (rutting, fatigue, sub-grade deformation, etc.) and may vary from less than 1 to over 18!



Source: Africon, 2010

Figure 7-1: Graph of the Exponential Relationship between Axle Loads and Road Damage

Table 7-1 illustrates the effect of Axle Load on the design life of a pavement that is loaded above a limit of 10 tonnes for varying power exponents.

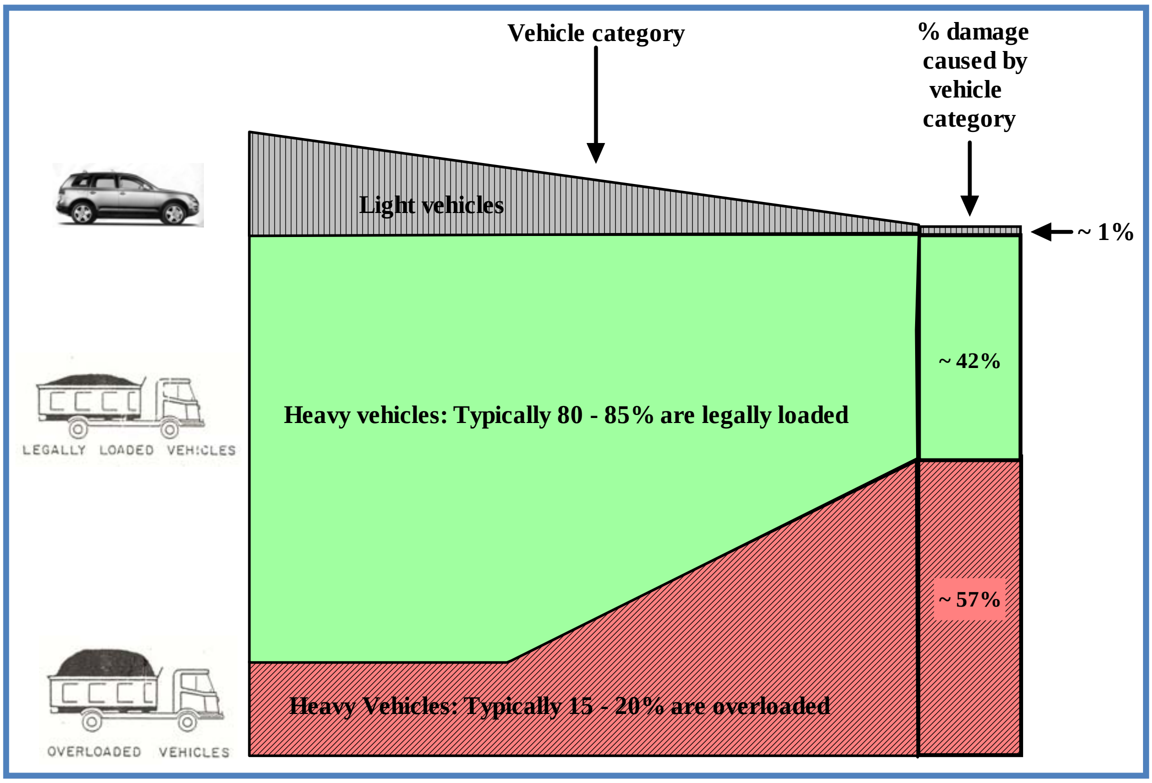
Table 7-1: Effect of Axle Loads on Pavement Life

Design Axle Load	Carried Axle Load	Equivalence Factor			Pavement Life (years) for Varying Power Exponent		
(Tonnes)	(Tonnes)	n = 4.0	n = 4.5	n = 5.0	n = 4.0	n = 4.5	n = 5.0
10.0	10.0	1.0	1.0	1.0	20.0	20.0	20.0
10.0	11.0	1.5	1.5	1.6	13.7	12.9	12.4
10.0	12.0	2.1	2.3	2.5	9.7	8.8	8.0
10.0	13.0	2.9	3.3	3.7	7.0	6.1	5.4
10.0	15.0	5.1	6.2	7.6	3.9	3.2	2.6

Source: Africon, 2010

The above table indicates, for example, that a single axle that is overloaded by just 20% over a limit of 10 tonnes, i.e. loaded to 12 tonnes, with an assumed power exponent of 4.0, has just over twice the damaging effect (equivalence factor = 2.1) as a legally loaded vehicle. Moreover, if the pavement were to be continually subjected to such overloading, its life would be reduced from 20 years to just less than 10 years! It is noteworthy that the effect of the Fourth Power Law on weak pavements can be catastrophic, whilst the effect does not apply significantly to over-designed pavements or gross vehicle mass.

The effect of the exponential relationship is that most road wear is caused by vehicles with more heavily laden axles; (ref. Figure 7-2) and a disproportionate share of road wear will be caused by overloaded vehicles.



Source: Africon, 2010

Figure 7-2: Contribution to Pavement Damage by Vehicle Category

As the size of a load approaches the design strength of a pavement or bridge, the effects of the load will be more significant. In these cases, a small number of passages of the load can cause significant structural damage. In an extreme case, a single passage of a grossly overloaded vehicle could cause catastrophic failure.

7.2.2 Bridges

The effects of load on bridges is thought to be more linear than is the case on pavements, with the life of a bridge and the maintenance requirements dependent on the number of passages and the size of the load. While road effects are related to axle mass, bridge effects can be related to either axle mass or gross vehicle mass, depending on the relationship between the axle spacing and the length of the bridge span. Hence, overloaded vehicles are a major contributor to bridge deck deterioration. The extent of deterioration depends on the design loading adopted for the bridge. The impact of overloaded axles on short span bridges (< 20 m) relates primarily to tandem and tridem axles. Vehicles that significantly exceed the legal GVM limit raise the prospect of bridge failures, particularly those with short spans and/or low design standards.

The type of damage which occurs due to overloading is of the following forms:

- Timber decks - local failure of timber deck planks, either longitudinal or transverse and loosening of attachment timber deck planks to supporting members. On timber girder bridges splitting has also been reported as a result of gross overloading.
- Concrete decks - cracking of concrete decks, sometimes leading to extensive crack patterns and the formation of block cracking, which in turn can lead to spalling of concrete from either the deck surface or the underside. Composite action between the concrete deck and its supporting members can also be compromised.

7.2.3 Road Safety

As the degree of overloading increases, major safety issues are raised in addition to non-recovery from the road user of damage to the infrastructure. These issues include:

- increased severity of accidents when overloaded vehicles are involved
- reduced grade climbing capability and acceleration causing congestion in mountainous terrain
- greater loss of lateral stability especially when cornering
- increased braking distance required for overloaded vehicles
- increased vehicle emissions, noise and ground-borne vibrations

7.2.4 Impact on the Transport Industry

Overloading places transporters who abide by the regulations at a disadvantage as they are not able to compete with those transporters that overload. This has an adverse, knock-on effect on the transport industry as some transporters then resort to overloading in order to be able to compete with those who overload. The net effect is that a transporter’s survival in a harshly competitive market is often related to how successful he is at getting away with overloading! Not surprisingly, therefore, overloading has become big business as in most cases the fines imposed by a court of law remain unrealistically low compared with the higher profit made by the transporter in transporting a heavier load.

7.3 Cost of Overloading

The marginal cost associated with an overloaded vehicle on a road comprises three main components:

- The increase in transport cost to other vehicles as a consequence of the overloading. This increase in transport cost reflects that the deterioration caused and results in increased costs for operating the vehicle and lower speeds, resulting in higher time costs. This increase is due to higher time cost incurred as a result of lower operating speeds necessitated by deteriorating road.

- Assuming that routine maintenance actions are condition responsive, overloaded vehicles on a road would lead to earlier and more frequent routine maintenance interventions.
- Overloading will lead to the road authority remedying the damage by way of periodic maintenance actions or reconstruction at an earlier date than would have been the case without the additional vehicle.

By way of quantifying the costs of overloading, tests undertaken by the South African Council for Scientific and Industrial Research (CSIR) in 2003 indicated that on a typical relatively high standard national road in South Africa, the additional damage over and above the legal payload is of the order of US $2,500 – $3,500 per km per annum. On a less substantial provincial road the additional damage would be of the order of

US $10,000 per km per annum and could even extend to over US $14,000 per km per annum depending on the design of the pavement.

7.4 Overview of Recent Regional OLC Initiatives

The abovementioned detrimental effects of overloading and the imperative to do effective Overload Control are all widely accepted and acknowledged. A number of initiatives have been launched in recent years to address various aspects relating to Overload Control in particular and the movement of road freight in general, all with the ultimate purpose to reduce the cost of transport and consequently trade for the region as a whole.

Recent significant regional initiatives include, but are not limited to:

- Meeting of the Technical Committee on Axle Load Limits Implementation in the East African Community, EAC Secretariat, August 2007; and
- Synthesis Report and Guidelines on Vehicle Overload Control in Eastern and Southern Africa, SSATP, March 2010.

Various issues and recommendations emanate from the above initiatives and are briefly summarised in the sections following:

7.4.1 Issues and Recommendations from EAC Technical Committee on Axle Load Limits

The following issues and corresponding actions were recorded by the committee:

Table 7-2: EAC Technical Committee Issues & Actions

No.	Issues	Recommendations	Status
1	Fines Vs Fees (charges for overloading)	Partner States should start charging economic fees that are commensurate with the damage caused by overload rather than Court fines. Overloading should be de-criminalised, removed from Court systems and handled administratively.	Process has started in Tanzania but not in the other member states.
2	Axle Load Limits	Partner States to adopt the 56 tonne maximum Gross Vehicle Weight that is operational in the SADC region.	Adopted in principle but legislation needs to be amended accordingly before implementation.
3	Tolerances on Axle load and Gross Combination Mass (GCM)	Adopt an overload tolerance level of a maximum of 5% for individual axles and the GCM, and transporters should be allowed to proceed *1	Generally accepted and applied.
4	Quadruple Axle	All Partner States to phase out quadruple axles by 1st December 2007.	Done

No.	Issues	Recommendations	Status
5	Calibration of Weighbridges	Calibration to be undertaken on the basis of usage (i.e. number of vehicle weighed) but the interval should not exceed six months. Calibration standards should be linked to the EAC Standards, Quality Assurance, Metrology and Testing (SQMT) harmonised standards.	Policy adopted. Formal maintenance regimes lacking.
6	Super Single Tyres	EAC will make a proposal after analysis of technical information on super single tyres on air suspension.	To be done
7	Lift Axles	The lift axles are acceptable in principle, subject to further analysis of technical supporting data. Partners States are requested to look into modalities of enforcing compliance of their usage within their legislations.	To be done
8	Vehicle with tandem steering axle on drawbar trailer (Dolly).	Kenya to provide accident statistics to support the relationship between the tandem steering axle and accident levels.	Unknown.
9	Weighing procedures, weighbridge certification and reporting formats.	EAC Secretariat to explore ways of developing uniform weigh bridge certificate and overload reporting formats, and linking these documents with customs clearance processes to ease cross border trade.	Guidelines document proposals could be adopted.
10	Networking of Weighbridges	The Partner States are urged to endeavour to network their weighbridges and a regional data centre be developed to link these weighbridges.	To be done
11	Vehicle dimensions	Partner States to harmonise the technical standards for vehicles.	To be done
12	Policy Differences in the treatment of excess import cargo	A policy on the 'chain of responsibility' for overloading should be developed by EAC Secretariat.	To be done
13	Treatment of abnormal and awkward loads	The EAC to institute a study on best practices with a view to developing a regional policy.	Refer to synthesis report and guidelines documents

Source: EAC Technical Committee Recommendations – Africon, 2010

The following additional recommendations were made by the committee and are in various stages of adoption:

- Encourage **Transporters Associations to be licensed** by the Transport Authorities in the region in order to have a code of conduct.
- Undertake **public awareness to sensitise consigners** on the axle limits so that they can comply before the cargo is offloaded at the Port.
- Encourage **establishment of weigh bridges at the Ports** so that any overloading can be detected and offloading of excess cargo enforced immediately at the Port.
- Encourage **real time integration of the automation of the weigh bridges** with the cargo tracking systems being implemented by the Revenue Authority in the Regional to ensure monitoring of the overloading along the corridors.
- **Transporters need capacity building** and therefore Partner States should undertake to sensitise the transporters to increase awareness in regard to existing legislations, procedures and practices.

- Partner States to establish a **common Bridge formula** to be use during road construction.
- Partners States to **encourage use of weigh in-motion weigh bridges** at busiest weighing sites.
- Partner States to explore other ways of **encouraging Public Private Partnerships** in the weigh bridge operations and maintenance.
- Establishment of a **technical committee to oversee** the challenges of new development in the road transport industry.

Although some of the above recommendations are for the action of the EAC Secretariat there are a number of initiatives that have to be carried out by the respective governments of the member states.

7.4.2 Guidelines on Vehicle Overload Control

The guidelines document, recently completed, provide comprehensive guidance to practitioners and officials tasked with Overload Control in the region to enable them to address most infrastructural and operational issues relating to weighbridges in particular and overload control in general.

In summary, the guidelines cover aspects such as:

- Selection, installation and operation of weighbridges
- Data collection, analysis and reporting
- Private sector involvement and financing mechanisms
- Cross border overload control, and
- Training of weighbridge personnel.

The above guidelines, as distinct from manuals, are of a generic nature in that they provide guidance to practitioners on the various aspects of overload control indicated above. Such guidance will need to be customised to the specific environment in which it is being applied and which will vary significantly between the various member countries of the EAC.

In order to secure an efficient overload control system it is necessary to consider all elements of such a system. While the issues addressed in these guidelines cover some of the important elements of a complete system, the following elements also need to be addressed:

- Legislation and regulatory framework
- Enforcement regulations
- Public support and awareness campaigns

In addition, there is also a need for an over-arching policy in each country that is harmonised with the regional policy and integrates the various elements of an overload control system discussed above.

Two of the matters discussed above are of paramount importance to enable the regional Overload Control initiative to gain momentum. These two issues are discussed in more detail in the following sections and they are the first element in the selection, installation and operation of weighbridges as described in the Guidelines document and, the harmonisation of axle load limits and vehicle dimensions across the member states of the region.

7.5 Strategic Deployment of Weighbridges

The strategic deployment of weighbridges in the region is of paramount importance and such deployment should be guided and co-ordinated regionally. To enable this there needs to be consistent and common criteria applied in the compiling of each country's OLC strategy and the consequential selection and prioritisation of weighbridges. One of a number of parameters used to determine positioning of weighbridges is the economic and financial rationale. This is discussed in the next few paragraphs.

7.5.1 Rationale for Overload Control

The technical rationale of overload control (OLC) is to ensure that legal loads, set at a level that minimises total transport costs to the national economy, are observed. Violation of these limits by overloading and associated premature distress of road infrastructure can be very costly to the national economy. Consequently, there is a very strong technical and economic rationale for controlling axle loads on the road network.

The economic rationale requires that the financial benefits of OLC should be greater than the cost of conducting the OLC. The financial benefits of OLC are equal to the saving in road damage costs due to overloading. The costs of overload control are equal to the capital costs to build the network of OLC facilities plus the operational and maintenance costs plus the road damage costs due to the overloading which still occur on the network (100% control of overloading is not practically possible).

The economic viability of overload control should be determined on an overload control network basis and not for individual weighbridges. The location of individual weighbridges within the network is therefore of critical importance. An overload control index is typically derived to ensure that individual weighbridge locations will be such that on a network basis the operation will be economically viable.

7.5.2 Overload Control Index (OLCI)

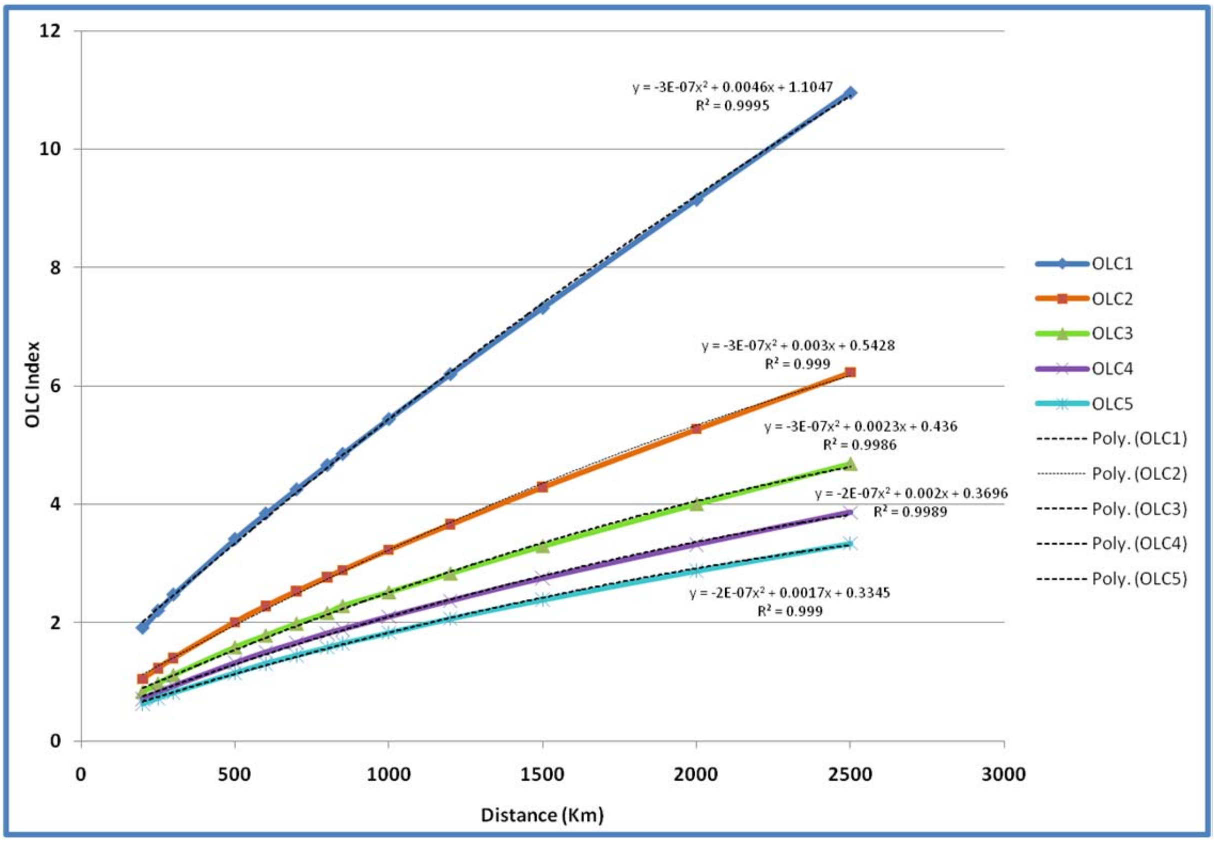
Economic viability of overload control should be determined over the full design life of the operation (assumed to be 20 years). In the first place the OLC initiative as a whole should be viable, i.e. the capital costs plus the operational and maintenance costs plus the remaining road damage which will still occur (because the OLC will never be 100% effective) must be less than what the road damage would have been if there was no OLC. In the second place the overload control activity as such should be viable, i.e. the saving in overload road damage as a result of the OLC should be more than the cost to carry it out (capital costs plus operational and maintenance costs).

In order to compare these costs and benefit aspects meaningful it is necessary to convert the different elements to a common factor which could be used to derive at an OLCI. The NPV technique was used for this purpose. The OLCI is therefore defined as:

$$OLCI = \frac{NPV(Do-nothing\_damage)}{NPV(Capex+Opex+Maintenance+Remaining\_OL\_Damage)} + \frac{NPV(OL\_Damage\_Saving)}{NPV(Capex+Opex+Maintenance)}$$

The OLCI must be greater than 2 for the OLC network to be financially viable over its entire lifespan.

The OLCI concept was also used to develop graphs which could be used to determine weighbridge locations. These graphs are shown in Figure 7-3.



Source: Africon, 2010

Figure 7-3: Recommended Number of Weighbridges per Road Length

The top graph was derived for only one weighbridge over the length of the road located more or less in the middle of the road, depending on where the intersecting roads are located. At a road length of 200 km or more this location layout becomes economically viable.

The second graph provides for weighbridges at the origin and destination ends of the road. At a road length of 500 km or more this location layout becomes economically viable.

For road lengths of 700 km or more the third graph can be used which requires weighbridges at the origin and destination ends as well as at midpoint.

Roads of a 1000 km or more would require four weighbridges located more or less at equal spacing depending on where the intersecting roads are located.

The last graph shows that for roads longer as 1200 km, five weighbridges are required more or less at equal spacing depending on where the intersecting roads are located.

The above calculations are but part of the issues to be considered when weighbridge deployment is considered. Other key strategic issues are discussed below.

7.5.3 Key Strategic Issues

In addition to the rationales discussed above the selection of a weighbridge is also determined by the purpose it will serve. The purpose will, in turn, be determined by the strategy adopted by the relevant institution. Before a weighbridge site or type is selected a number of critical aspects need to be addressed:

- Regional and National strategies: It is necessary and important for the institution responsible for overload control to have a comprehensive strategy that deals, as a minimum, with matters of policy and regulation, operational approach and in this context provides some guidance on available budget. If this aspect is not addressed, the tendency is to utilise funds on infrastructure in an incoherent way resulting in weighbridge facilities being sub-optimally located, improperly operated and inappropriately equipped. This all leads to ineffectiveness and waste.

- Operational strategy: The design of a weighbridge facility is the direct result of the intended operational strategy – or in simple language, the weighbridge must be designed for the way it will be used.
- Prioritisation: Within this overall national strategy, prioritisation can be undertaken with regard to the deployment of weighbridges across the country's road network. It is recommended that the 80:20 principle or 'Pareto Principle' be adopted. The application of this principle with regard to the prioritisation of weighbridges countrywide or across a region will result in weighbridges being located on roads with the highest heavy vehicle traffic volumes and where the greatest impact can be achieved with the least cost and effort.

7.5.4 Weighbridge Deployment in the Region

7.5.4.1 Current and weighbridges:

Current deployment of weighbridges in the region is depicted in the map shown hereafter.

7.5.4.2 The Freight Corridors

The included map also depicts the main road freight routes, indicating estimated traffic volumes in 2010 ADT values combined to percentage heavy vehicles. It is clear that a number of freight corridors dominate the region namely the Mombasa – Nairobi – Kampala freight corridor, the Northern corridor and the Dar es Salaam – Dodoma – Isaka – Burundi corridor , the central corridor, and Dar es Salaam – Iringa – Zambia border, the Southern corridor.

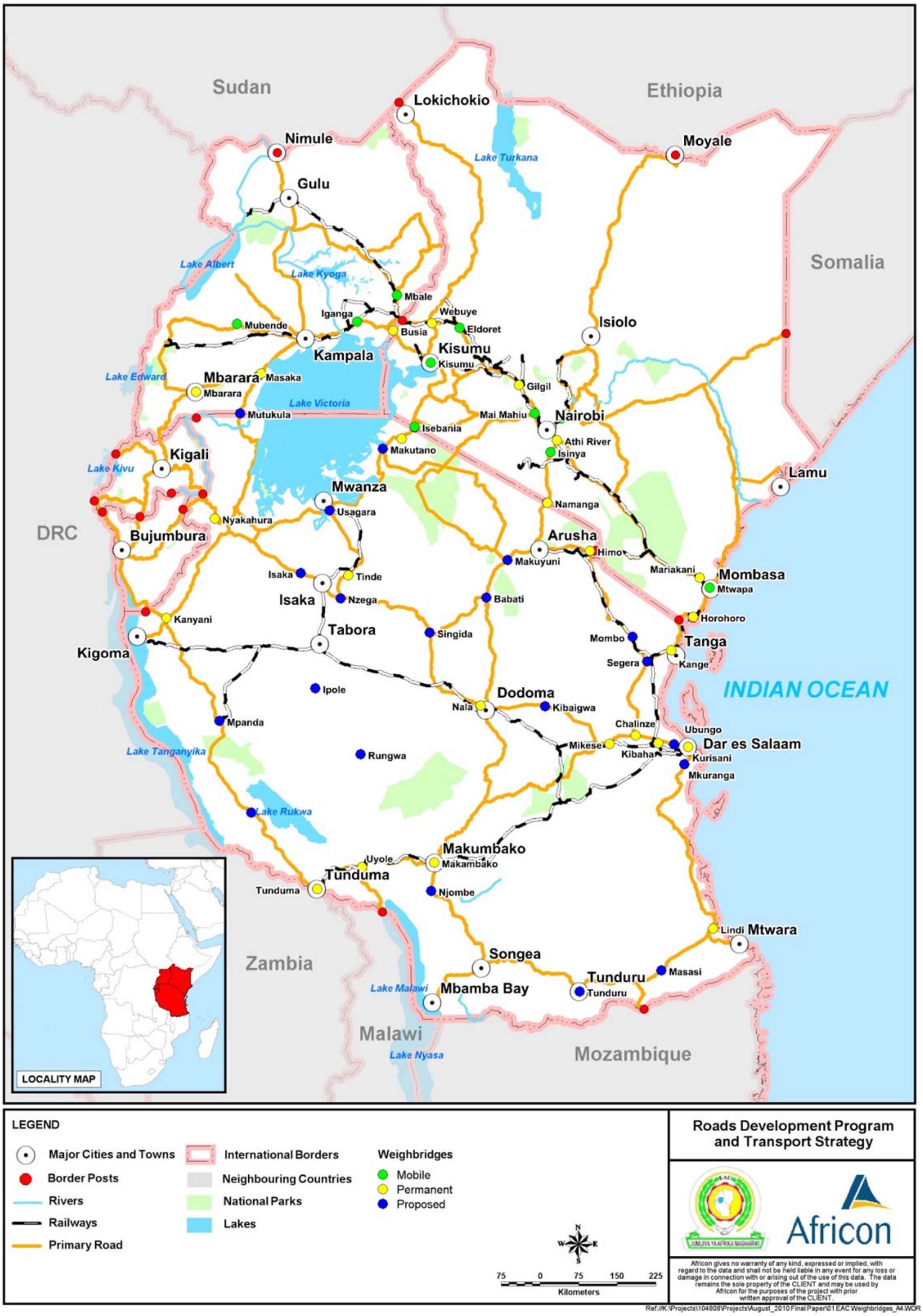
As could be expected the largest heavy vehicle movements are around the main cities. All three corridors carry more than 75% heavy vehicles – which is extremely high. Although other routes carry significantly less traffic, the heavy vehicle percentages are still between 50% and 75%, also very high.

7.5.4.3 Routes Lacking OLC

Most routes are well protected in terms of strategic placement of weighbridges. There are however some routes carrying significant heavy vehicle traffic but are entirely unprotected, such as the Dar es Salaam – Mtwara route, the Dodoma – Arusha route, and the Tanga – Arusha route in Tanzania.

In Kenya there are three weighbridges around Nairobi, the Mariakani Weighbridge at Mombasa and the border weighbridges at Kisumu and Webuye. The road from Nairobi to the Tanzania border at Lake Victoria as well as the Nairobi to Isiolo routes is vulnerable. The routes between Nairobi and neighbouring countries like Sudan, Ethiopia and Somalia seem unprotected. Traffic volumes; however low still pose the risk of heavy overloading and consequent damage to pavements.

Generally heavy vehicles travel very long distances in the region and as indicated before the damage caused by a heavily overloaded heavy vehicle could cause tremendous damage to a very long section of road.



Map 7-1: Location of weighbridges in the EAC

7.5.4.4 Recommended Weighbridge Locations

As indicated in Map 7-1, it can be seen that the proposed weighbridge sites in Tanzania cover the whole network of roads in the country.

From the above preliminary review indications are that n Kenya some consideration should be given to placing weighbridges on the route between Nairobi and Isiolo and at all the border posts with neighbouring countries such as Somalia, Ethiopia and Sudan.
In Uganda there seems to be no weighbridges on the road to Southern Sudan via Nimule, this road should also be protected by the construction of an overload control facility.

Traffic numbers and consequently heavy vehicle traffic in Burundi and Rwanda is comparatively low. Nevertheless, their borders should be protected and overload control around Kigali would be advisable.

7.6 Harmonisation of Vehicle Load and Dimension Limits

The second and one of the most important aspects that needs to be addressed to ensure the OLC regional initiative to gain momentum is the harmonisation of vehicle load and dimension limits. The effectively puts all member countries on a level playing field and does a lot to simplify the hauler's life.

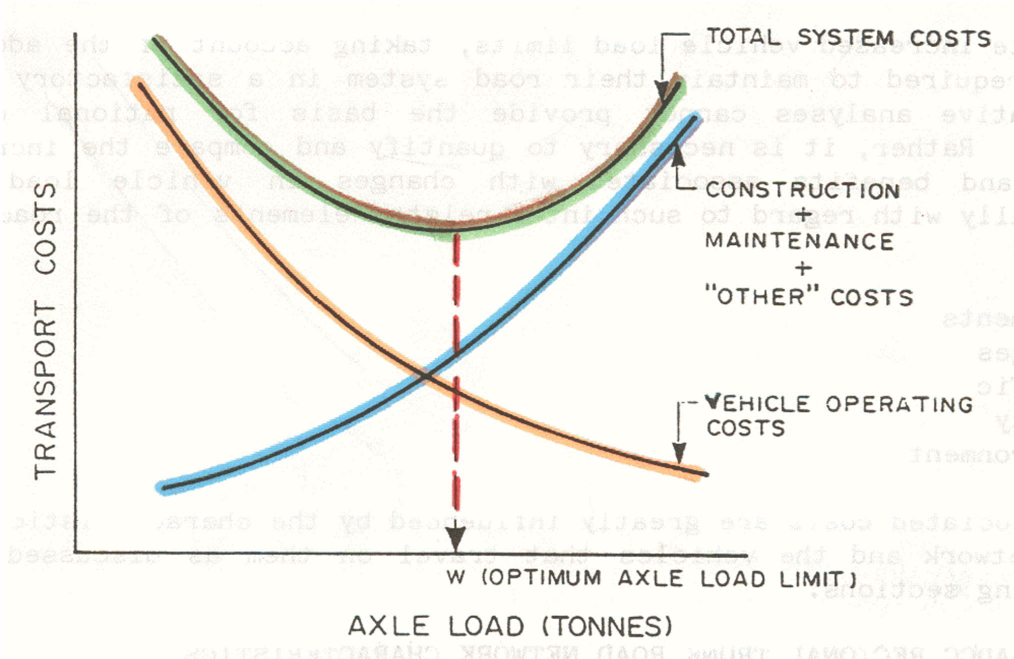
7.6.1 The Importance of Harmonisation

The importance of harmonisation of axle load limits and vehicle dimensions cannot be over emphasised. There is fortunately an apparently good understanding by the member states of the implications of not having regional harmonisation. As can also be seen from the deployment of weighbridges (ref Map) most of the weighbridges in the region are located at border crossings. The three major transport or freight corridors in the region also traverse a number of states and regional harmonisation is therefore imperative. It is very disrupting to have a heavy vehicle passing legally on the first part of its trip only to be apprehended later on in its trip after it has crossed a border into a neighbouring country with lesser limits. There are many more issues with respect to harmonisation which should be dealt with in each country's own OLC strategy.

7.6.2 Recommended Limits

In order to expedite the harmonisation of axle load limits and vehicle dimensions, this section gives some comparison of the status quo, explains some of the most important work done to optimise limits in the SADC region and recommends limits to be adopted.

The recommended axle load and gross combination mass limits for the SADC Regional Trunk Road Network (RTRN) are based on a study for Southern Africa which was carried out in 1993 to determine the optimum axle load limits, i.e. such axle loads and weights that will minimise the total transport cost on a regional basis in the SADC region. This concept is illustrated in Figure 7-4 which shows the various inter-acting elements in relation to the derivation of the optimum axle load limits.

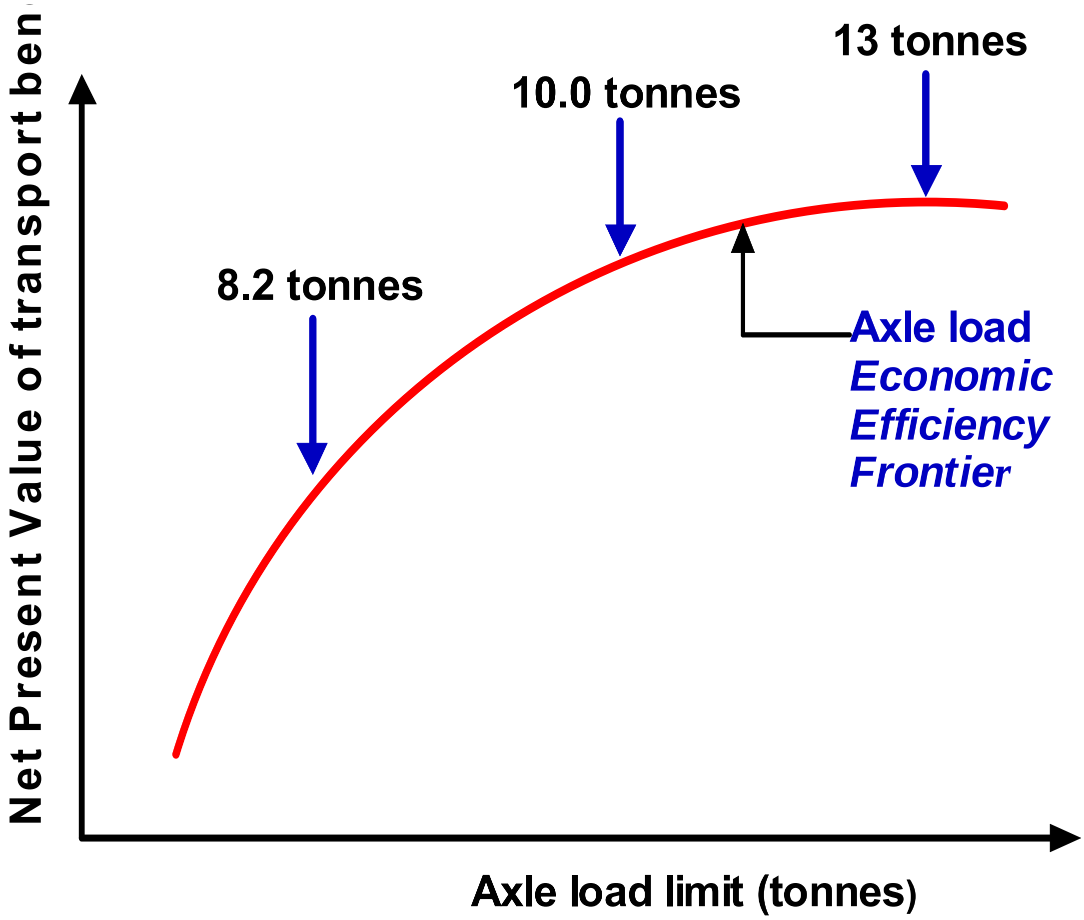


Source: Africon, 2010

Figure 7-4: The concept of the Economic Axle Load Limit

The important assumption used in the SADC study is that axle load regulations should be based on a trade-off between road haulage cost and costs related to road and bridge wear. Simply stated, this means that axle loads and gross vehicle weights should be increased to the point where the savings to the hauls affected from a further increase is less than the increase in costs due to the additional wear on roads and bridges. The analysis was undertaken using the World Bank's Highway Design and Maintenance Standards Model (HDM-III).

Based on the outcome of the HDM-III analyses, the regional optimum single axle load limit was determined as 13.0 tonnes. However, based on consideration of the axle load Economic Efficiency Frontier, in terms of the benefits versus costs of increasing from the prevailing limits to the optimum limit (ref. Figure 7-5 and Table 7-3), the harmonised limits recommended for the region were less than the optimum limits, as shown in Table 7-3.



Source: Africon, 2010

Figure 7-5: Axle load Economic Efficiency Frontier

Table 7-3: NPV of transport costs in relation to increase in axle load

Increase in axle load limit		Benefit/cost ratio
From	To	
8.2	10.0	10.1
10.0	12.0	3.6
12.0	13.0	1.7

In addition to axle load economic efficiency considerations, there were a number of other reasons for recommending limits which were less than the optimum limits. These included the large proportion of sub-standard pavements, a significant amount of backlog maintenance and concern over the adequacy of future maintenance funding. In the event, the recommended regional axle load and gross combination mass limits for the SADC region are as follows:

Table 7-4: SADC recommended harmonised axle load limits

Maximum Axle Load Limits (Tonnes)				Gross Combination Mass (GCM) (Tonnes)
Single		Tandem	Tridem	
Steering	Drive			
7.7	10	18	24	56

7.6.3 Harmonisation of Regional Axle Load Limits

In practice, there is still lack of harmonisation of axle load limits amongst EAC countries and for that matter also SADC countries. For example, as shown in Table 7-5, single axle load limits of 8.0, 8.2, 9.0 and 10.00 tonnes still prevail and such variation also occurs with tandem, tridem and GVM limits. There is however are significant measure of agreement which could be exploited to reach full agreement.

Table 7-5: Existing axle load limits in the region (EAC Countries highlighted)

Country	Steering Axle Two Tires	Single Axle Dual Tires	Tandem Axle Dual Tires	Tridem Axle Dual Tyres	GCM (Tonnes) (max)	Weighing Tolerance
Angola	6	10	16	24	38	
Botswana	7.7	8.2	16.4	24.6	50.2	5%
Burundi	-	-	-	-	-	-
Kenya	8	8	14	24	48[1]	5%
Lesotho	7.7	8.2	16.4	21	49	
Malawi	8	10	18	24	56	
Mozambique	7.5	10	16	24	38*	Nil
Namibia	7.7	9	18	24	56	5%
Rwanda	-	-	-	-	-	5%
South Africa	7.7	9	18	24	56	5%
Swaziland	7.7	8.2	16.4	21	50.2	
Tanzania	8	10	18	24	56	Nil
Uganda	8	8	16	24	56	5%
Zambia	8	10	16	24	56	10%
Zimbabwe	8	10	18	24	56	5%
COMESA	8	10	16	24	56	-
SADC	7.7	10	18	24	56	5%
EAC Prop	8	10	18	24	56	5%

Table Notes:

1. *Kenya GCM of 48 Tonnes: Kenya is in the process of revising their allowable axle load limits at present with indications being that the 48t allowable axle load limit will be upwardly adjusted to 56t.*

7.6.4 Harmonisation of Vehicle Dimension Limits in the Region

As shown in Table 4.3, there is much less difference in vehicle dimension limits within the region which tend to be more uniform as regards, for example, vehicle combination length (20 - 22 m), vehicle width (2.5 - 2.65 m) and vehicle height (4.0 - 4.6 m). In any event, there is a Working Group on Vehicle Dimensions and Combinations which has made proposals on obtaining event greater harmonisation in this area.

Table 7-6: Existing Vehicle Dimension Limits (EAC Countries Highlighted)

Country	Vehicle Combination Length (m)	Articulated Vehicle Length (m)	Width (m)	Height (m)	Rigid Vehicle Length (m)	Trailer Length (m)	Semi-Trailer Length (m)
Angola	20	18	2.5	4	15	15	15
Botswana	22	17	2.5	4.1	12.5	12.5	12.5
Burundi	-	-	-	-	-	-	-
Kenya	22	17	2.65	4.2	12.5	12.5	12.5
Lesotho	22	17	2.6	4.1	12.5	12.5	12.5
Malawi	22	17	2.5	4.6	12.5	12.5	12.5
Mozambique	18/22 *	15	2.5	4	12	12	12
Namibia	22	18.5	2.6	4.3	12.5	12.5	-
Rwanda	18	17.4	2.65	4.2	-	-	-
South Africa	22	18.5	2.6	4.3	12.5	12.5	-
Swaziland	20	17	2.5	4.1	12.5	12.5	12.5
Tanzania	22	17	2.65	4.6	12.5	12.5	12.5
Uganda	22.5	17	2.5	4.0	12.5	12.5	12.5
Zambia	22	17	2.65	4.6	12.5	12.5	12.5
Zimbabwe	22	17	2.65	4.6	12.5	12.5	-
COMESA	22	17	2.65	4.6	12.5	12.5	12.5
SADC	22	18.5	2.6	4.6	12.5	12.5	-
EAC Prop	22	17	2.65	4.6	12.5	12.5	12.5

Harmonisation of vehicle dimensions is crucial to cross-border co-operation and regional integration. The above recommendations are therefore proposed to enable conclusion of agreements in this regard and the respective governments are thus invited to start with the process of amendment of legislation and regulation to be able to implement the above.

7.7 Summary of Recommendations and the Way Forward

As could be seen from the above, there are many issues surrounding the topic of Overload Control and some are multifaceted. This section seeks to prioritise and summarise the recommendations in a manner to guide decision makers as to the short and medium term programme priorities.

As a **first priority** EAC region and each member state should respectively commission the compilation of an OLC strategy. The EAC region needs to have an **overarching regional Overload Control strategy** based on the work done and reported above. Each country should commission and implement a **country specific Overload Control strategy**. The reason why each country needs to do this separately is to ensure that each country identifies and addresses the unique situation prevalent in its country, e.g. some countries need to make legislative changes and others not, some need to establish new institutional vehicles and others not and different countries need to make different changes to policies to fir into a harmonised whole. These policies will guide the actions following.

The **second priority** flowing from the first should be the **harmonisation of axle load limits and vehicle dimension standards**. Some proposals are included above with the rationale behind it. There is furthermore a great variation in vehicle types in use in the region which makes it extremely difficult to design scales and software to handle all possible options. A logical consequence of the above would thus be to guide the registrations of new vehicles to eliminate too many variations over time.

A **third priority** should be **agreements to establish smoother cross-border operations** to reduce the OLC effort required at border posts.

A **further priority** should be the **standardisation** of weighing equipment, procedures and interpretation of enforcement guidelines leading to integration of data collection and collective reporting. This cannot be done without training – according to standardised training programmes region-wide. An economy of scale is then also possible for proper preventative maintenance regimes, calibration requirements and human resources resulting in lower life cycle costs.

Other priorities that will need attention to establish a stable and sustainable solution include the adoption of **innovative contractual arrangements** to involve private sector in the appropriate areas of the OLC initiative. Areas such as maintenance management, data collection and reporting are typical areas where private sector has proved to be beneficial and cost effective.

An aspect not to be under estimated is the value that **public awareness** adds to the whole initiative. It entails the education and encouragement of all the parties involved in the freight industry to see the benefits and to contribute to a better future that is sustainable, fair and more cost effective for all.

Lastly there are a number of **other technical issues** that are of a lesser importance to gain momentum but are important in the long term sustainability of the initiative such as: policies on excess cargo imports, abnormal loads, licensing of transporter associations, the use of unconventional technology for the detection of overloading and weight distance charging.

8. INTEGRATED ROAD NETWORK MANAGEMENT SYSTEMS

8.1 Introduction and Definition

The definitive purpose of a road network is to support and sustain social and economic development within a country and is therefore widely regarded as the lifeblood of a country. A road network in its entirety is therefore an important asset that needs to be looked after (managed) and by disregarding its importance and upkeep will result in unnecessary and otherwise avoidable costs to a country's economy due to increased vehicle operating costs, higher accident rates, longer travel times, transport damage, etc.

Management and specifically a Management Framework is very important and enable management decisions to be made in a structured manner that is logical and consistent. It provides guidance on the type of decisions that must to be made, the purpose of those decisions, who needs to make them, when must they be made, the information needed to make the decisions, etc. A Management Framework, when looking at roads, can therefore assist in improving the quality of decision-making, and can result in greater effectiveness and efficiency for both customers of the road network and the road administration (Robinson, 2000).

An idealised Management Hierarchy can be demonstrated as follows:

Figure 8-1: Management Hierarchy

There are limited definitions specifically for defining an Integrated Road Network Management System (IRMS) due to the numerous systems that form part thereof (ranging from Pavement Management Systems, Asset Management Systems, Road Safety Management Systems, Bridge Management Systems, Congestion Management Systems, etc.

An Integrated Road Network Management System (IRNMS) is therefore identified in the transport industry as the management system that brings all road management systems together, and can be defined as:

'An all-encompassing framework, including both information processing and human resources, for the integrated management of the road network, including the determination and optimisation of the economically warranted projects, programmes, strategies and budgets, for both development and maintenance.' – (Tekie, 2005)

An IRNMS is therefore an essential component of a country's road network and a crucial tool that allows decisive decisions to be made based on accurate information.

Integrated Road Network Management requires a comprehensive understanding of all elements involved in the roadway environment and the users interacting with this environment.

This section aims to provide a broad description of an IRNMS and its important components. Furthermore, this section will identify key Management Systems (as part of the IRNMS) that are required urgently to be implemented within the EAC in order to provide a sound foundation that will enable decision makers to manage the EAC Road Network (EAC Road Corridors and Corridor Feeders) effectively and efficiently.

8.2 IRNMS Foundation Structure

An IRNMS is broadly structured around two (2) imperative systems or components, namely:

- Information System
- An Information System collects, organises and stores data about the Road Network[4]
- Decision-Support Systems
- Decision-Support Systems comprise of application modules that enable the processing of the data and provide the information on which decisions can be based and, ultimately, implemented.
- Decision-Support Systems are generally defined further in terms of the following:
  - Planning
  - Programming
  - Preparation, and
  - Operations

Based on the above and broadly speaking, an IRNMS is therefore founded on the following management levels or functions:

[4] It is important to note that an Information System caters specifically for a specific organization that deals with a specific road network of a country. For example the South African Roads Agency Limited (SANRAL) as per their mandate is only concerned with the National Roads of South Africa and therefore their Information System collects, stores, and organizes information regarding all National Roads of South Africa. In the case of the EAC therefore, such a Road Network Information System would contain information with regards to the EAC Road Corridors and Corridor Feeders.

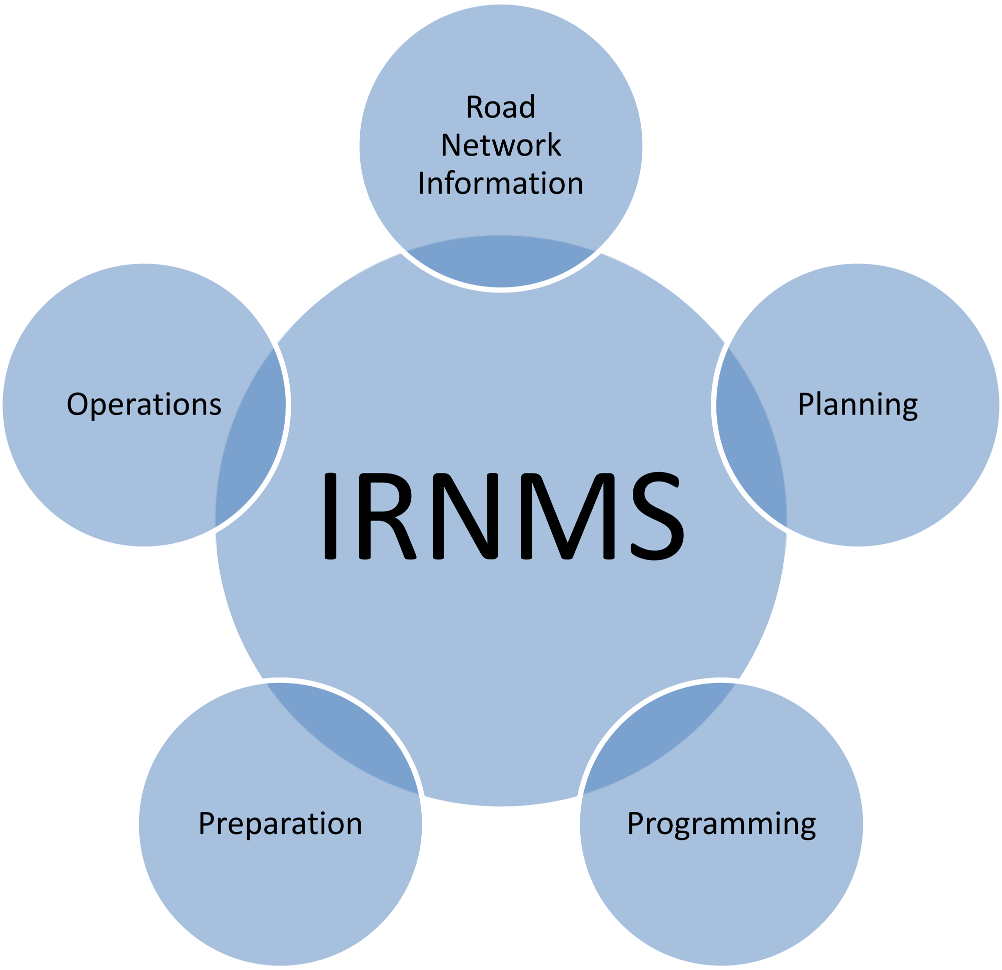


Figure 8-2: An IRNMS Management Structure

With regards to Figure 8-2 above, the following detail is provided:

- Road Network Information
- A Road Network Information System, as defined above, containing data about the EAC Road Network (EAC Road Corridor and Corridor Feeder Network) and is central to Management Systems that form part of an IRNMS such as, but not limited to, for example, Pavement Management Systems, Bridge Management Systems, Traffic Management Systems, Road Safety Management Systems, etc.).
- Planning
- Decision-support system for strategic planning undertaken to develop long term plans for the EAC Road Network as a whole; planning time horizons typically of five years or more; undertaken to determine what are the implications resulting from meeting objectives in terms of future budget needs, consequential pavement conditions, user costs, etc.
- Programming
- Decision-support system for tactical planning or programming concerned with determining need in the budget year; planning time horizons of one to three years; including identification of links or sections from the network which require treatment and the timing of treatments, possibly in conjunction with a rolling programme; cost estimating, prioritisation, budgeting, monitoring.
- Preparation

- Decision-support system for project preparation, including project formation and design, costing, works order or contract preparation and issue.
- Operations
- Decision-support system for the management of operations on a daily or weekly basis, including defining work to be carried out, developing appropriate costs for this in terms of labour, equipment and materials, and making arrangements for carrying out the work by force account or by contract, the recording of work accomplishment, and the use of this information for monitoring and control.

Decision-Support Systems (as part of the IRNMS) can also be seen in terms of a sequence of planning and management operations. As these move from planning through to operations, the following changes in procedure normally occur:

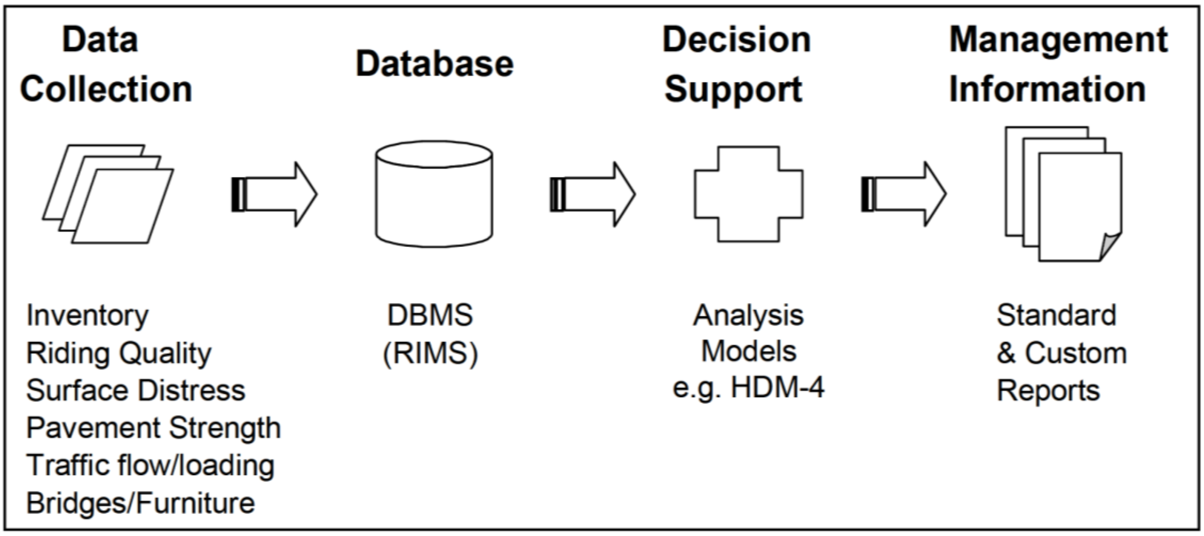
- The road sections considered change from all those contained in the network to only those where works are required and likely to be carried out;
- The time horizon being considered changes from multi-year, to budget year, and then to the current week or day;
- The data used change from being summary or sampled, to detailed with full coverage over the part of the highway covered by the project; and
- Processes undertaken by the computer change from being automatic, to being undertaken by the user working interactively with the computer.

Key benefits to organisations that adopt integrated road management systems and practices include:

- Improved understanding of service level options and requirements
- Minimum life cycle (long term) costs for an agreed level of service are identified
- Better understanding and forecasting of asset-related management options and costs
- Managed risk of asset failure
- Improved decision making based on costs and benefits of alternatives
- Clear justification for forward works programmes and funding requirements
- Improved accountability over the use of public resources
- Improved customer satisfaction and organisation image

Road management planning enables government road organisations to demonstrate to their customers and other stakeholders that services are being delivered in the most effective manner. It also provides a basis for evaluating complex service price/quality relationships in consultation with customers.

The following sections however, shall provide more detail regarding the components of an Integrated Road Network Management System (refer to Figure 8-3).



Source: Kerali, H. Road Asset Management Principles, Workshop, University of Birmingham, 2002

Figure 8-3: Components of an IRNMS

8.3 Road Network Information System – Data Collection and Database Management

For any informed decision on policies or activities related to roads, at least two elements of information are necessary and required:

- An inventory of the roads in a network, including their basic specifications. This maybe a list of roads linking geographically defined points, but much better is a detailed list of technically homogeneous road sections.
- A description of the present condition of each road or road section; this information is determined through a periodical inspection of the entire network.

This is also the basic foundation information that must be in place in order to be able to calculate the value of the EAC Road Network asset as a whole. If this information is not available, any attempt to plan or evaluate road management cannot happen due to decision makers not being able to base any decision on facts. - (Schliessler & Bull, 2004)

8.3.1 Approach to Road Network Data and Information Design

The outputs from an IRNMS are produced from a combination of data and models. Therefore, the definition of the outputs required will determine the data items that need to be collected and stored within the system. The choice of models will also influence data requirements, since models combine data items and parameters, using pre-defined algorithms and relationships, to produce further data items. Note that the cost of data acquisition is likely to be the most expensive aspect of implementing and operating an Integrated Road Network Management System (IRNMS).

8.3.1.1 Data Collection

The key characteristic surrounding data collection for road management is to only collect the amount of data that is required to provide the necessary management information. For purposes of road maintenance for example, it is necessary to ensure that the minimum data collected provides information on the road inventory, pavement condition (riding quality, surface distress, and pavement strength), and traffic characteristics. The cost of data acquisition can be very expensive, and will often be the most expensive aspect of implementing and operating a road management system. System operation, itself, is likely to cost between two and four per cent of the maintenance budget provision. As such, it is essential that appropriate data design is undertaken if cost-effective results are to be obtained. Consequently, data collection for road management will often include the data groups summarised in Table 8-1.

Table 8-1: Typical Data Groups associated with Road Management

Data Group	Aspects	Examples
Road Inventory	• Network • Furniture • Environs	Location, Geometry Appurtenances, Signs, Lights, Culverts Terrain, Rainfall
Pavement	• Structure • Condition	Layers, Materials Surface distress, Riding quality, Structural performance
Structures	• Structures inventory • Structure condition	Bridges, Retaining walls, Tunnels Traffic damage, Failures, Weathering
Traffic	• Volume • Loading • Accidents	AADT, Traffic mix, 24-hour volumes ESAL (E80) Severities, Rates
Finance	• Costs • Budget • Revenue	Unit costs, Out-turns Limits, Ceilings, Allocations Tolls, Fines, User charges
Activities	• Projects • Interventions • Commitments	Progress record, expenditure, time scales Standards, Work types, Work effects Budgets, schedules
Resources	• Personnel • Materials • Equipment	Staff, grades, salaries, Quantities, storage, unit costs Outputs, consumption, unit costs

Source Kerali, H. Road Asset Management Principles, Workshop, University of Birmingham, 2002

As the management process progresses from planning, through programming and preparation to operations, the amount of data detail required have a tendency to increase gradually in intensity, however the extent of its network coverage is reduced. This feature can be used to assist the data design process by combining the functional levels of road management with ***information quality levels*** **(IQL)**. These provide a standardised definition devised by the World Bank, of the level of detail of different data items, such that they are of a consistent accuracy for different functions.

- IQL-I
- Most detailed and comprehensive level of data. Collected on short to limited lengths of road, or isolated samples, using specialised equipment. Data collection is slow except when using advanced automation.
- IQL-II
- Detailed data. Collected on limited lengths of road using semi-automated methods; or full network coverage using advanced automation at high speed.
- IQL-III

- Summary data with categorisation of values. Collected on the full network using high-speed, low accuracy semi-automated methods; or on a sample basis at slow speed. Alternatively, information can be obtained by processing other data.
- IQL-IV
- Most summary data. Collected manually, or using semi-automated methods. Alternatively information can be processed or estimated.

The selection of data items to be collected must therefore satisfy the following criteria:

- Relevance
- having a direct influence on the required output
- Appropriateness
- both to the stage of planning and management process, and to the authority's capability to undertake the required data collection
- Reliability
- in terms of accuracy, coverage, completeness and correctness
- Affordability
- in both financial, and staff requirement, terms

Data collected will depend on the particular management strategy used in the road administration. This, in turn, depends on the approach adopted by the administration for each of the four management functions. Typical strategies are summarised below.

Strategy A

High-level condition data (typically IQL-IV) are collected across the whole network each year. This is used for planning and programming purposes. The programming exercise then collects more detailed data (typically IQL-III) on those sections where works are likely to be undertaken. More detailed data (typically IQL-II) are then collected on some of the sections for which designs are produced, or for which works are undertaken. As more detailed data are collected on any section, they replace that collected in the earlier phase, with the result that different sections in the database store data at different levels of detail.

Strategy B

Relatively detailed data (typically IQL-II/III) are collected across parts of the network on a rolling programme, perhaps with a cycle of three to five years. Each year, programming decisions are taken either using current data for individual sections, if available, or by projecting forward condition data from previous years. Thus all condition data tends to be stored at the same level of detail, although data collected as part of the works design or execution processes may also be stored.

Other strategies

Other combinations of the above are also used, including the following examples:

- Annual data can be collected on the primary road network, whereas a cycle of data collection may be used on roads lower in the hierarchy
- The cyclic approach can be used for the whole network, but collecting data at low levels of detail (IQLIII/IV)
- Cyclic collection methods can be used without projection of condition. Some administrations collect detailed data annually across the whole network, although this approach is unlikely to stand up to investigations of cost-effectiveness

All have different implications for the level of data detail stored in the database of the road management system.

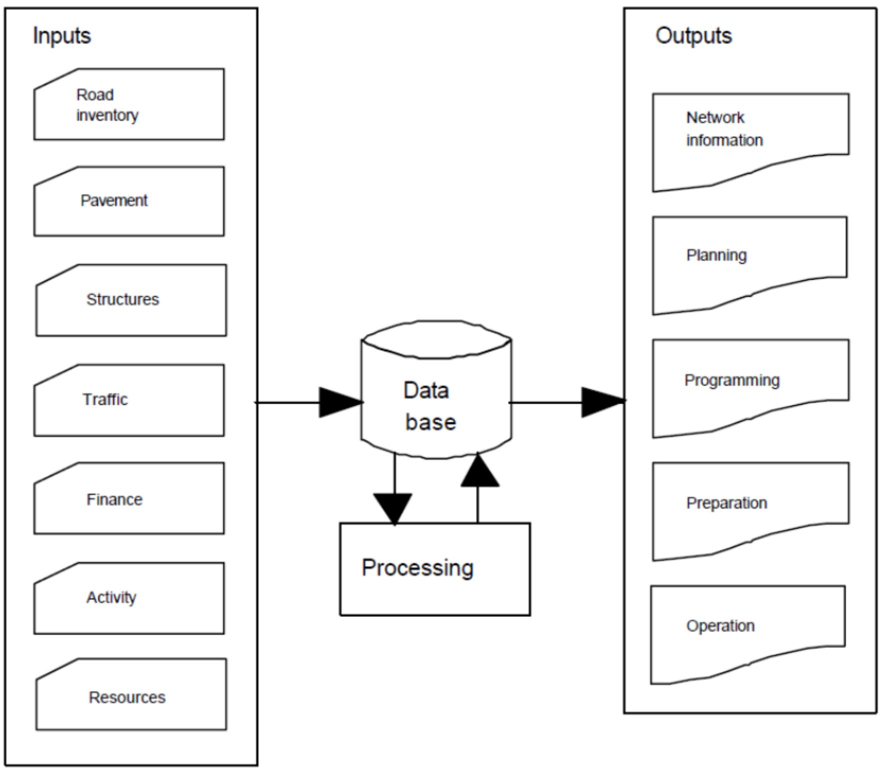
8.3.1.2 Database Management

A Database Management System (DBMS) is an effective way of managing data of an IRNMS and provides quick and easy access to data for purposes of preparing management information (be it pavement management information, traffic management information, etc.).

Normally, the most efficient and flexible information structure for a road management system is one that is modularised (refer also to Figure 8-4), with integration achieved through a common database. This modular structure should reflect the manual operation of the road management process when broken down into functions and tasks. Many proprietary systems lack this modularity and are only available as complete systems, with a resulting loss in flexibility and ability to match the physical management structure.

With modular software, the database forms the backbone of the management system. This comprises the network referencing system around which is built an inventory of the network, and provides the framework within which all information about, or associated with, the network is stored and retrieved. The DBMS software must be flexible enough to accommodate future changes and growth. Although such an integrated approach should be a long-term target, in the medium-term, most road management systems may only contain part of the complete system. In many cases, it will be appropriate for a road organisation to implement a subset of the complete system, then to add more features and functions as the capability within the organisation grows. This approach represents an ideal situation and does have long-term benefits.

Different parts of the system can be developed independently, at different times depending on the resources available, using different software products. The main disadvantages are that considerations that relate to the long-term may dictate short-term actions, with the result that the initial solution may be more expensive and complicated than a dedicated application.



Source: Robinson,R. A New Framework for Road Management, 2000. Robinson, R. Selecting Road Management Systems, 1997

Figure 8-4: Modular Information System Framework

8.4 Decision Support and Management Information

8.4.1 Decision Support

The purpose of a decision support tool is to provide the key management information that will assist senior policy makers and managers within the road organisation in the decision-making process. The primary role of the decision-support tool is to transform the data collected into meaningful information for the different management levels within an organisation. This will often require use of models, rules, knowledge-bases and other data processing techniques. It is essential that whatever data processing techniques are applied, they must be open (i.e. not a black-box) and be based on well-published research, procedures, or standards, that is well understood by both the management and technical staff within the road organisation. The transparency of analysis will determine the degree to which the road organisation will trust and believe in the results produced by the decision-support system.

For purposes of road management, the decision-support tool should incorporate principles of life cycle cost analysis as this forms the framework for medium and long term planning. Consequently, the Highway Development and Management tool (HDM-4) is often seen as a good decision support tool that serves the needs of road management.

8.4.2 Management Information

The starting point in determining management information is that it must be relevant to the decision-making process at various levels within a road management organisation. Most organisations are structured into several layers of management responsibility starting with the chief executive or chief engineer at the top, down to the technical staff who are responsible for day-to-day tasks (e.g. works supervisors, technicians, junior engineers, etc.) A decision needs to be made regarding what levels of management within the organisation will require information from the road management system. This must be accompanied by exact definitions of the types, contents and formats of the management information required at each level.

In general, the management information may be classed into 3 groups:

- Performance Indicators
- – Information that can be used by the road organisation and by the public to measure how well the road network is managed. Such information includes predicted network performance trends, average travel speeds and average travel costs over a number of years.
- Operational Statistics
- – Information of a quantitative nature that is used mainly within a road organisation to assess budget needs, to measure annual achievements and to make judgements on the effectiveness and efficiency within the organisation.
- Decision Criteria
- – Information utilised by middle ranking management and technical professionals to make decisions regarding annual work programmes and to select between project alternatives. These include prioritised lists of road projects and/or the economic indicators of project viability.

8.5 A Word on Sustainability of Road Management Systems

In simple terms, to sustain something is to support something and prevent it from collapse.

Sustainability in the road management context means that there is strong will, commitment and resources within the organisation to maintain, operate and subsequently improve the road management system by using local resources and staff.

Consequently, the implementation of a sustainable road management system should consider:

- Existing institutional arrangements and any required changes;
- The relevance and need for management information produced;
- The capability of the agency to collect the required data and keep them current;
- Technical knowledge required to operate and subsequently improve the system if and when the need arises;
- Knowledge and computer skills available within the agency (if a computerised system is adopted);
- Staff training programmes in the area of pavement management.

Pavement management systems that have been introduced in many developing countries are often too complicated and too demanding to be sustainable. In determining the requirements of a road organisation it is therefore necessary to consider the capacity of the organisation in terms of financial and human resources required to operate the system. Consequently, to ensure sustainability, each component of the road management system has to be designed such that the organisation is able to maintain and operate the system using local resources at minimum cost. At the same time, the system should produce realistic and technically feasible management information within available resources. This includes the requirements for data collection, updates of the decision-support tool, and maintenance of the database management software.

8.6 Conclusion and Recommendations

This Chapter has presented a holistic framework of an Integrated Road Network Management System for the EAC Secretariat based on international best practices.[5]

When implementing a road management system, it is important that a road organisation should consider the following:

- The proposed data collection scheme;
- Procurement of the required hardware and software;
- Necessary training of key staff responsible for operating the system;
- Acquisition of computer knowledge and skills required to maintain and upgrade the system.

The most critical parameters are human resource constraint and time required to collect the data.

Underestimating the time required to collect, input and validate the data into a road management system is often a common hindrance to sustainability. In general, for the sustainability of a road management system, road organisations should consider using simple but technically compatible methods in the development and implementation of the system. These methods are particularly recommended for developing countries that cannot afford expensive high-tech solutions.

It is therefore recommended that the EAC, as part of its Transport Strategy and Regional Roads Sector Development Program establish an Integrated Road Network Management System for the EAC Road Corridors and Corridor Feeders. The IRNMS should follow the guiding foundation principles recommended in this report especially

[5] It is important to note that no detailed investigations were conducted for each of the EAC member states as part of this Chapter. However, a comprehensive EAC IRNMS is proposed which should include detailed investigations for the EAC as a whole.

with regards to Road Capacity and Road Condition on critical Road Corridors such as the Northern Corridor and Central Corridor (as a start).

It is recommended that relatively detailed data (typically IQL-II/III) are collected across parts of the network on a rolling programme, with a cycle of three to five years. Each year, programming decisions are taken either using current data for individual sections, if available, or by projecting forward condition data from previous years. Thus all condition data tends to be stored at the same level of detail, although data collected as part of the works design or execution processes may also be stored.

It is therefore important that the EAC establish, as a priority, a Database Management System as described in this report as soon as possible in order to form the backbone of the EAC IRNMS. This comprises the network referencing system around which is built an inventory of the EAC road network, and provides the framework within which all information about, or associated with, the network is stored and retrieved.

A Comprehensive Traffic Observation Programme is recommended for the collection, management and dissemination of road traffic data – year-on-year rolling – one year per Member State (i.e. 5-year rolling programme) encompassing dedicated and fixed counting stations at critical locations (at least 50 counting stations per Member State).

9. PRODUCTIVITY INDICATORS

In accordance with the Terms of Reference for this study, this section on productivity indicators strives to analyse and propose benchmarks for assessment of projected improvement in the performance of the road links, including reduction of road transportation cost and transit times, improved level of maintenance and utilisation, as well as other productivity indicators, based on a comparative analysis of level of performance of other similar but more efficient transport corridors elsewhere in the World.

In order to apply this productivity indicators approach to the roads environment, the consultant team applied the First Oder Network Assessment (FONA) methodology used to assess the road capacity bottlenecks for the EAC road network. The FONA methodology was applied to comparative corridors in the South African road environment in order to benchmark the operational performance of EAC corridors with similar corridors in South Africa.

9.1 Corridor Comparison Selection

In order to effectively prepare comparative benchmarks for transport corridors in the EAC, corridors of similar characteristics had to be selected. The following characteristics were applied in the corridor selection exercise:

- Corridors should be of major economic importance to the region
- Corridors should service a major port at either its origin or destination
- Corridors should be characterised by higher heavy vehicle / freight volumes
- Corridors should service multiple regions or geographies

The following Major Trade Corridors were therefore selected in terms of the abovementioned selection exercise (refer to Table 9-1 below).

Table 9-1: Major Trade Corridors of the RSA and the EAC

Region	Corridor	Length (km)
RSA	National Route N3 – Connecting Johannesburg and Durban	**579**
	National Route N4 – Botswana Border to Mozambique Border via Pretoria	**815**
EAC	Central Corridor – Dar es Salaam – Morogoro – Dodoma – Singida – Nzega – Nyakanazi – Kigali - Gisenyi	**3,127**
	Northern Corridor – Mombasa-Voi-Eldoret-Bigiri-Kamala-Masaka-Kigali-Kibuye-Kayanza-Bujumbura	**1,926**

Source: Africon, 2010

Note: Lengths are approximate

9.2 Major Trade Corridor Comparison

The selected Major Trade Corridors were compared in terms of the following characteristics:

- Geometric Characteristics
- Traffic Characteristics
- Operational Characteristics

9.2.1 Geometric Characteristics

With regards to Geometric Characteristics the following was investigated and compared (refer to Table 9-2 below):

- Number of Lanes
- Terrain Type (Level; Mountainous; and Rolling)
- Travel Speed

Taking into consideration the **Number of Lanes** and referring to Table 9-2 below, the following observations can be made:

- The RSA Corridor National Route N3 for the large part, has two lanes (94.8%) per direction of its total length; whereas the National Route N4 has mostly 1 lane per direction (77.5% of its length) as well as two (2) lanes per direction for 22.5% of its total length.
- The EAC Central and Northern Corridors have both for the largest part of their respective lengths one (1) lane per direction (97.7% and 91.7% respectively).

With regards to the **Terrain Type** and referring to Table 9-2 below, the RSA Corridors and EAC Corridors compares as follows:

- The RSA Corridors are for the most part characterised by a level terrain type (N3 = 77% of its total length; N4 = 83.6% of its total length)
- The EAC Central Corridor is characterised by a level terrain type for 48.1% of its total length and a rolling terrain type for 51.9% of its total length
- The EAC Northern Corridor is characterised by a rolling terrain type for a large part (90.7%) of its total length.

With regards to the **Travel Speeds** and referring to Table 9-2 below, the RSA Corridors and EAC Corridors compares as follows:

- The RSA Corridors are characterised by high travel speeds (77% and 83.6% of their respective lengths
- The EAC Corridors are characterised by lower travel speeds of between 70km/h and 80km/h; and between 80km/h and 90km/h respectively

Therefore, given the observations made above regarding Table 9-2 below, the following conclusions can be drawn:

- The RSA Corridors are characterised by higher travel speeds, which could be attributable to level terrain characteristics and higher number of lanes.
- The EAC Corridors are characterised by lower travel speeds which could be attributable to rolling terrain type characteristics together with mostly having only 1 lane per direction.

9.2.2 Traffic Characteristics

With regards to Traffic Characteristics the following was investigated and compared (refer to Table 9-3 below):

- Percentage Heavy Vehicles
- Traffic Volumes (30^{th} Highest Hourly Volumes per Direction)

Taking into consideration the **Percentage Heavy Vehicles** and referring to Table 9-3 below, the following observations can be made:

- Between 21-30% heavy vehicles form the largest part of the traffic stream on the RSA Corridors.
- More than 50% of the traffic on the EAC Corridors consists of heavy vehicles.

With regards to **Traffic Volumes** and referring to Table 9-3 below, the following observations can be made:

- Of the Traffic Volumes on the RSA National Route N3 Corridor, 64% range between 200 – 2000 vehicles and 21.1% are more than 2000 vehicles (30^{th} highest hourly traffic volumes per direction).
- Of the Traffic Volumes on the RSA National Route N4 Corridor, 81% range between 200 – 2000 vehicles and 5.3% are more than 2000 vehicles (30^{th} highest hourly traffic volumes per direction).
- Of the Traffic Volumes on the EAC Central Corridor, 90.6% fall below 200 vehicles with only 9.4% ranging between 200 – 2000 vehicles and 0% more than 2000 vehicles (30^{th} highest hourly traffic volumes per direction).
- Of the Traffic Volumes on the EAC Northern Corridor, 48.8% fall below 200 vehicles with 51.2% ranging between 200 – 2000 vehicles and 0% more than 2000 vehicles (30^{th} highest hourly traffic volumes per direction).

Therefore, given the observations made above regarding Table 9-3 below, the following conclusions can be drawn:

- The RSA Corridors are characterised by higher traffic volumes with lower numbers of heavy vehicles
- The EAC Corridors are characterised by lower traffic volumes and higher numbers of heavy vehicles

9.2.3 Operational Performance Characteristics

With regards to Operational Performance Characteristics the base year Level of Service (LOS) was investigated (refer to Table 9-4 as well as Figure 9-1 below). The following observations can be made:

- The RSA National Route N3 Corridor operates at LOS A 59.3% of its total length.
- The RSA National Route N4 Corridor operates at a spread between LOS A, B and C for 24.4%; 24% and 20.8% respectively of its total length
- The EAC Central Corridor operates at LOS B and C for 41.1% and 49.5% of its total length
- The EAC Northern Corridor operates at LOS D and E for 36.8% and 42.1% respectively of its total length.

Table 9-2: Geometric Characteristics

Region	Corridor	Length (km)	Number of Lanes			Terrain Type			Travel Speed			
			1	2	3	Level	Mountain	Rolling	70km/h	80 km/h	90 km/h	100 km/h
RSA	National Route N3	579	0.1%	94.8%	5.2%	77.0%	7.2%	15.9%	0.0%	7.2%	15.9%	77.0%
	National Route N4	815	77.5%	22.5%	0.0%	83.6%	5.6%	10.8%	0.0%	5.6%	10.8%	83.6%
EAC	Central Corridor	3,127	97.7%	2.3%	0.0%	48.1%	0.0%	51.9%	4.8%	46.1%	49.0%	0.0%
	Northern Corridor	1,926	91.7%	8.3%	0.0%	6.8%	2.5%	90.7%	43.4%	48.4%	8.1%	0.0%

Notes: The above percentages represents a percentage of the total length of a specific corridor that reflect a specific geometric characteristic

Source: Africon, 2010

Table 9-3: Traffic Characteristics

Region	Corridor	Length (km)	% Heavy Vehicles						Traffic Volumes (30th Highest Hourly Volumes per Direction)					
			<10%	11-20%	21-30%	31-40%	41-50%	>50%	<200	200-500	501-1000	1001-1500	1501-2000	>2000
RSA	National Route N3	579	9.5%	0.0%	43.5%	34.6%	12.5%	0.0%	14.5%	20.8%	25.8%	10.6%	7.1%	21.1%
	National Route N4	815	20.0%	2.2%	63.9%	13.9%	0.0%	0.0%	13.6%	37.6%	25.6%	12.2%	5.6%	5.3%
EAC	Central Corridor	3,127	0.0%	48.1%	0.0%	0.0%	16.3%	35.6%	90.6%	7.7%	1.2%	0.3%	0.2%	0.0%
	Northern Corridor	1,926	0.0%	31.5%	0.0%	0.0%	17.2%	51.3%	48.8%	44.7%	6.3%	0.3%	0.0%	0.0%

Notes: The above percentages represents a percentage of the total length of a specific corridor that reflect a specific traffic characteristic

Source: Africon, 2010

Table 9-4: Operational Performance Characteristics

Region	Corridor	Length (km)	Base Year - Operational Performance (LOS)					
			A	B	C	D	E	F
RSA*	National Route N3	579	59.3%	8.7%	14.6%	8.0%	4.2%	5.2%
	National Route N4	815	24.4%	24.0%	20.8%	18.1%	10.8%	2.0%
EAC**	Central Corridor	3,127	2.1%	41.1%	49.5%	6.5%	0.7%	0.0%
	Northern Corridor	1,926	5.7%	7.6%	6.8%	36.8%	42.1%	0.9%

*Notes: *Base Year (2005)*

***Base Year (2010)*

The above percentages represents a percentage of the total length of a specific corridor that reflect a specific performance characteristic

Source: Africon, 2010

9.3 Major Trade Corridor Comparison Summary Conclusions

With regards to the observations made in the previous sections the following conclusions can be summarised:

- Although the RSA Corridors are characterised by higher travel speeds and higher traffic volumes, the majority operates at a higher LOS, which could be attributable to level terrain characteristics and higher number of lanes.
- Although the EAC Corridors are characterised by lower travel speeds and lower traffic volumes, the majority operates at a lower LOS, which could be attributable to rolling terrain type characteristics, and a large heavy vehicle presence together with mostly having only 1 lane per direction.

Therefore, it is clear that by addressing Geometric and Traffic Characteristics on the EAC Corridors, an improved LOS can be determined.

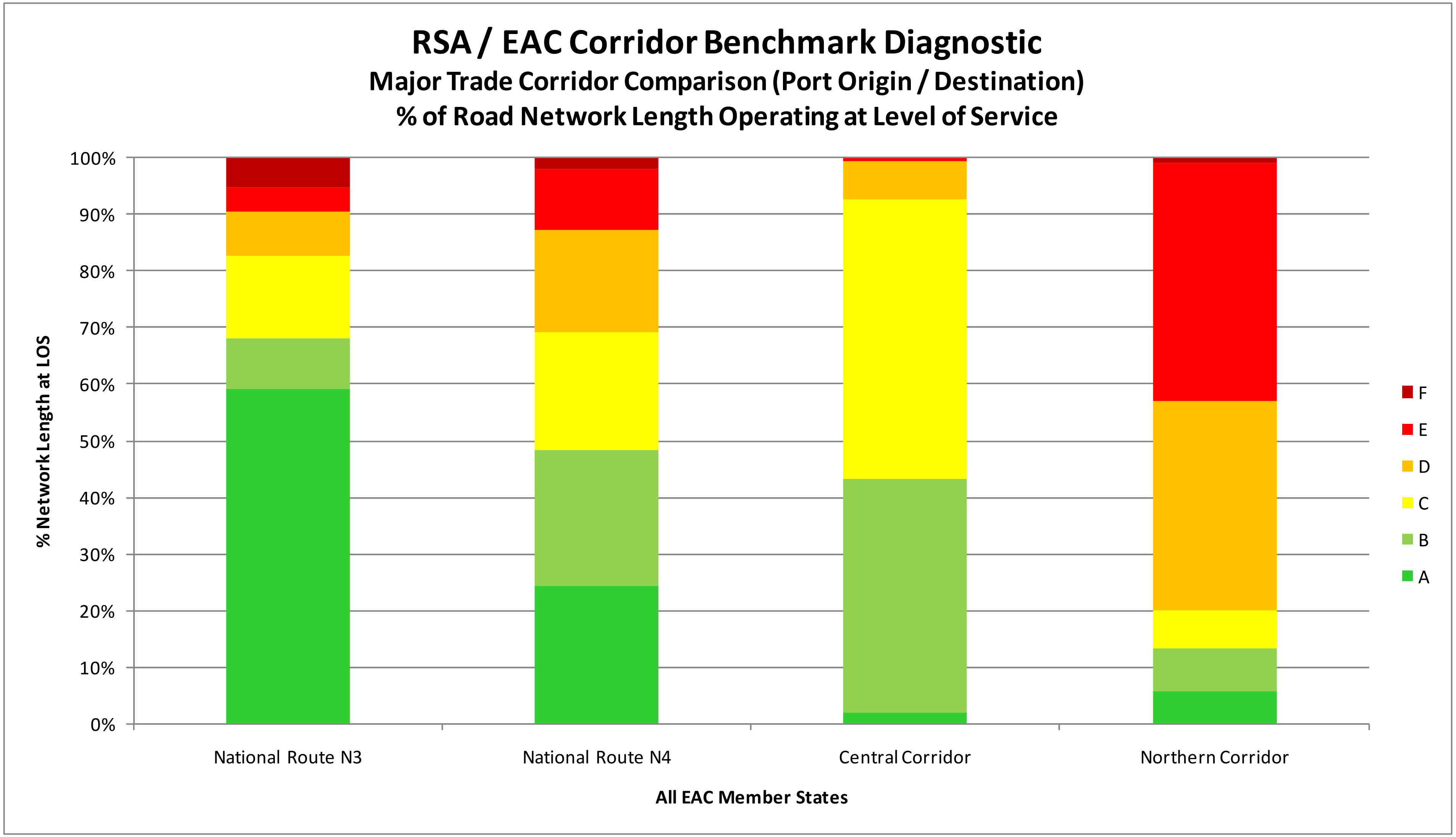
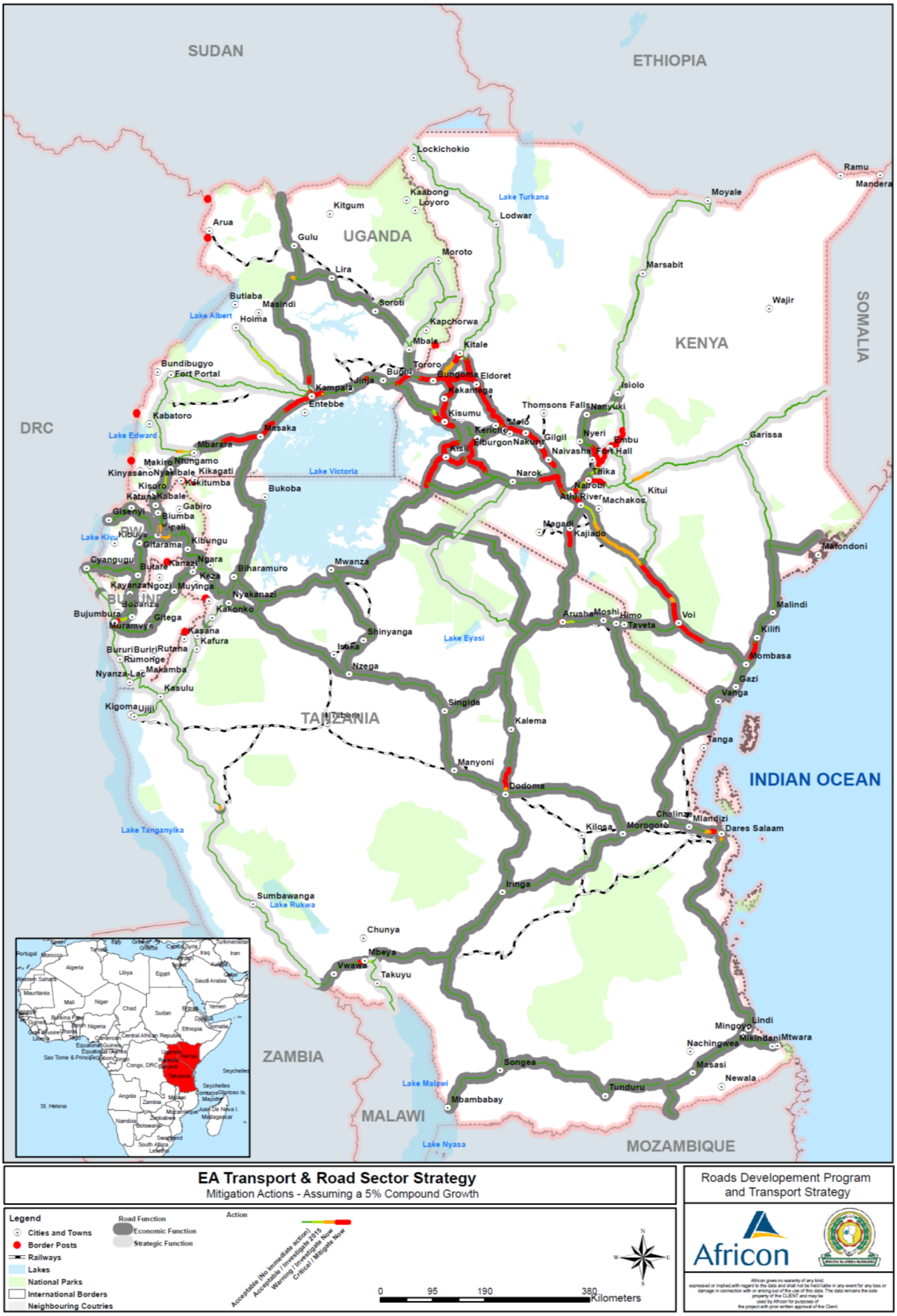
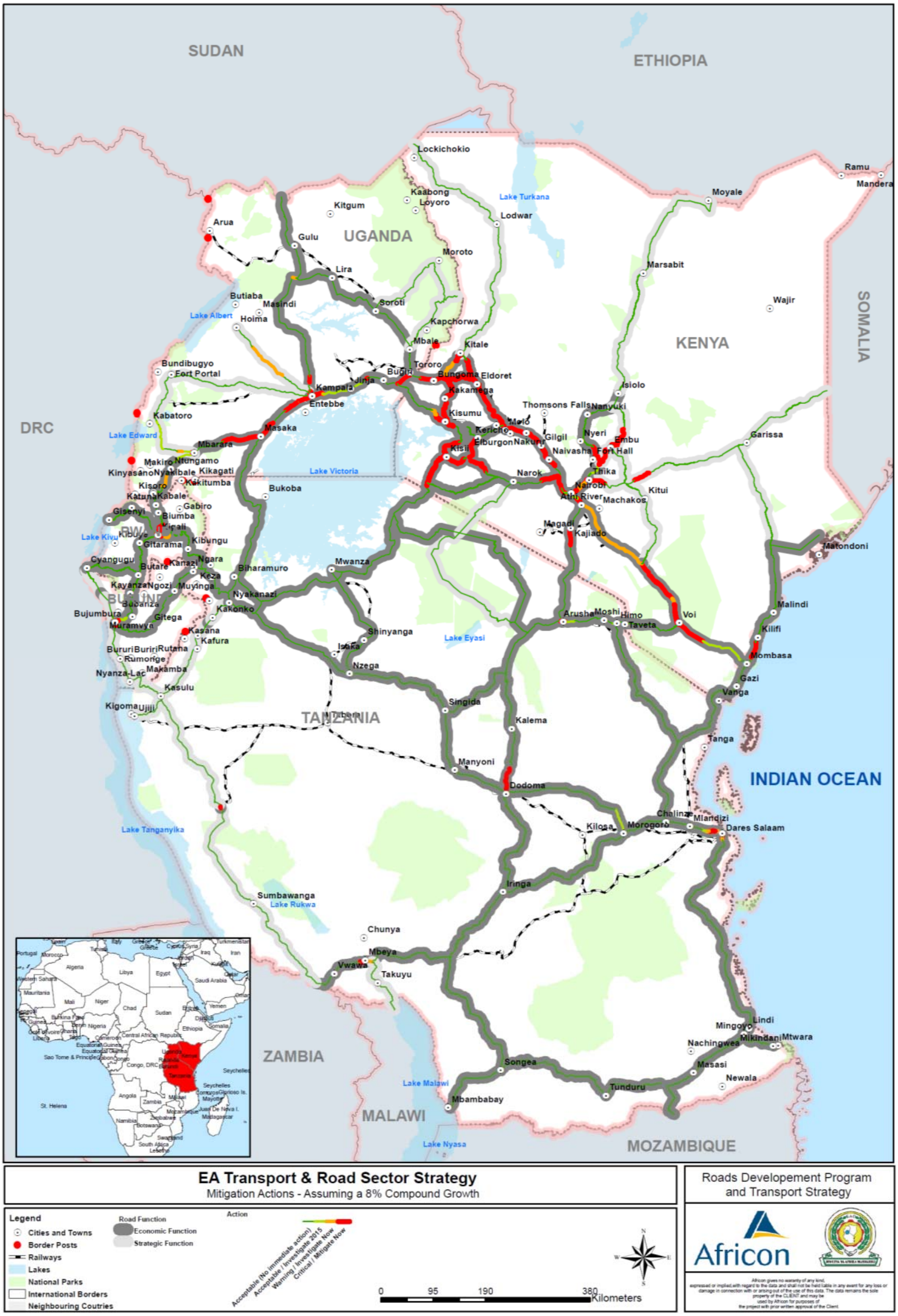


Figure 9-1: Major Trade Corridor Comparison – Percentage of Road Network Operating at Level of Service

Source: Africon, 2010



Map 9-1: FONA Results Scenario 2020 5% Growth – Mitigation Actions



Map 9-2: FONA Results Scenario 2020 8% Growth – Mitigation Actions