WALAILAK JOURNAL
Applied Sciences
http://wjst.wu.ac.th https://doi.org/10.48048/wjst.2021.9703

# Implementation of 5.1 Sidra Intersection Software for Appraisal of Road Corridors under Current Form

**Dagimwork Asele MANUKA**

*Department of Civil Engineering, College of Engineering, Wolaita Sodo University, Wolaita Sodo, Ethiopia*

**(Corresponding author e-mail: dagimworka@gmail.com)**

*Received: 25 March 2020, Revised: 23 July 2021, Accepted: 30 July 2021*

**Abstract**

The major goal of this study was to compute the flow appearances of the chosen midblock and to evaluate the road sections using various performance metrics that analyzed these road sections in both current and future conditions. Performance measure of flow parameters was at the operational period of the road. Therefore, this work examined the 2-way 2-lane roads with various performance measures. The capacity of mid blocks was also determined by plotting capacity curves and the level of service arrived and Sidra Intersection 5.1 tools were used for the analysis. All midblock evaluated with different performance measures both in current and future conditions with basic considerations. The analysis was done by adopting Sidra Intersection 5.1 tool and showed that 2-way 2-lane roads in future conditions were studied and the result indicated that their average travel speed, degree of saturation, practical spare capacity, total effective capacity, demand of flow, and level of service (LOS) displayed major changes from the base condition.

**Keywords:** Capacity, Demand of flow, Degree of saturation, Midblock, Performance measure

## Introduction

Stated that study of the various road traffic characteristics is essential for plan, design, and operation, regulation, and control of traffic roadway facilities. These characteristics are studied by observing various aspects of traffic flow in the field, which are difficult and time-consuming. When different categories of vehicles share the same road space without any physical separation, the extent of vehicular interactions differs widely with variation in the traffic mix. Vehicles, under heterogeneous traffic conditions, different types of vehicles moving on the same road system may enjoy different levels of service. For instance, at higher traffic flow, a large proportion of motorized 2-wheelers can move with speeds closer to their free speeds because of their ability for utilizing smaller gaps in the stream, while the large-size vehicles are subjected to considerable speed reduction. This complex traffic scenario, prevailing particularly on urban roads in developing countries, poses a serious encounter to traffic planners and engineers who are in the search out of suitable solutions. Solutions to the traffic problem are found through systematic study of all the relevant characteristics of mixed traffic as much as possible [1]. Flow, speed, density, and headway are the critical parameters used to describe the characteristics of traffic flow at the macroscopic and microscopic levels. A traffic flow fundamental diagram is used to characterize the relationship between these 3 macroscopic parameters and plays an important role in traffic flow theory and traffic engineering, as well as distinguishing traffic flow from another fluid modelling. In traffic flow dynamics, flow-density relation models used are to analyse shock wave propagation characteristics and traffic flow stability. In capacity analysis, speed-flow relation models use to determine the level of service. Vehicle time and space headway are used in distribution models widely applied in traffic engineering fields since they reflect the fundamental uncertainty in drivers' car-following manoeuvres and meanwhile provide a concise way to describe the stochastic feature of traffic flows [2].

**Study area**

Hawassa city is one of the reform cities in the country of Ethiopia and it has a city administration consisting of 8 sub-cities and urban as well as rural kebeles. Hawassa city is a fast-growing city and has large industry parks, construction of Ethiopia - Kenya trunk road, and Hawassa - Mojo express freeway roads in transport aspect, which enhance movement along with the city. The total population for the city of Hawassa is exceeding 315,000 and the annual population growth rate is 4.02 % based on the 2016 census data of the Ethiopian statistical agency. An enormous increase in traffic flow activity from time to time along the various corridors within city is highly observed due to the above activities.

**Related work**

According to [3] in plan, design and operation of the transportation system, traffic characteristics define the quantitative and qualitative natures of the vehicular flows are being accommodated on that system. The interaction of facility, driver, and vehicle will be expressed in various measurable parameters of traffic flow, and understanding traffic characteristics is fundamental to the development of any transportation system and traffic engineering activity [3]. The general characteristics of traffic movement are described by flow rate or volume of vehicle, speed or time rate of movement, and density or concentration of vehicles. Along with [4] transportation is generally concerned with efficient, safe, and sustainable movement of people and goods. Transportation engineers work on various aspects of the 5 stages essential in the life cycle of a transportation facility, which are planning, designing, building, operating, and maintaining. In the planning stage, typically forecast traffic demands for a future year or analysis period will be done and perform a preliminary evaluation of alternative solutions or identify priorities for system improvements. In the design stage, interested in specific geometric elements of the selected alternative, such as horizontal and vertical alignment for the proposed facility. After building the facility, the focus shifts to operations and maintenance. In the operations stage, it concerned with control algorithms (such as ramp metering), traffic management, and other aspects of operations such as incident removal. The maintenance stage involves regular upkeep and repairs such as resurfacing and re stripping as well as traffic signal control maintenance. Traffic flow theory relates primarily to the operations stage, but its tools and methods are used throughout the spectrum of transportation analysis. Traffic flow theory is part of transportation that is concerned with the capacity and traffic operational quality of transportation facilities. The traffic flow theory and its relationship with the infrastructure are shown below in the (**Figure 1**)

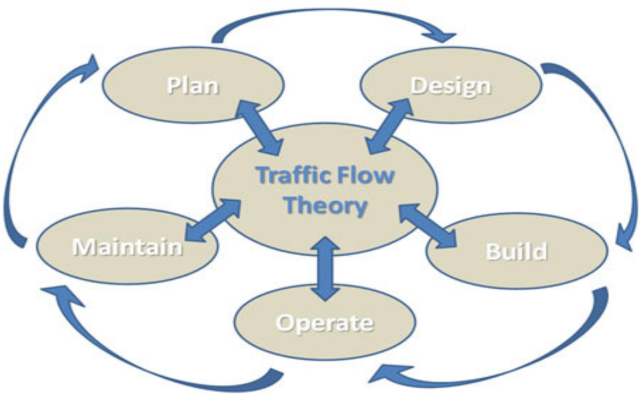


**Figure 1** Traffic flow theory and its relationship to transportation infrastructure [4].

The traffic and transportation engineering is to control traffic stream onset of the road network, to improve the flow without inducing undesirable side effect to society at large [5]. To be capable of developing effective system designs and control strategies, engineers must understand how the system may respond to possible engineering changes. In particular, they should be able to predict any figures of merit that are relevant to the affected public and should have an intuitive feel for likely response of the system to control or redesign, which is good when the time comes to develop a shortlist of potential improvements for further evaluation [5]. Analysis of these parameters will directly influence the scale and layout of the proposed highway, together with the type and quantity of materials used in its construction. This process of examination is termed traffic analysis and the sub-sections below deal with relationships between the parameters, which lie at its basis. In addition to this, the space between consecutive vehicles is important to observe the delivery gap between vehicles [6]. A given flow of traffic through streets and highways varies in both time and direction. Describing this traffic flow stream in terms of both to understand the variability in their flow characteristics and to define normal range of behaviour, to do the key traffic flow parameters should be defined and measured. Based on quantitative data, traffic engineers will evaluate, analyse, and plan improvements of traffic and transportation facilities [7].

The macroscopic parameters of traffic flow characteristics are flow rate, speed, and density and from this volume and flow rate are 2 measures that quantify the amount of traffic passing a point on a lane or roadway during a designated time interval. Volume is the total number of vehicles that pass over a given point or section of a lane or roadway during a given time interval and volumes may be expressed in terms of annual, daily, hourly, or sub-hourly periods. Meanwhile, flow rate is the equivalent hourly rate at which vehicles pass over a given point or section of a lane or roadway during a given time interval less than 1 h, usually 15 min [8].

**Parameters of flow characteristics**

The volume of traffic is count by using persons involved, which are called enumerators in the manual counting method. It is required to count the traffic data in a particular mid-block of a corridor. In that case, a baseline is to be drawn at the selected mid-block location and the enumerators will stand nearer to the baseline. Enumerators have to prepare a traffic volume, datasheet consisting of all types of vehicles moving along that road as per time with 15 min consecutive intervals of time [9]. Whereas in the automatic method, detectors are used to recognize the occurrence of the vehicle on the road and they to place below the baseline and that machine will automatically record the number of vehicles. The advantage of this method, it needs less manpower and the major disadvantage of this method it counts only all the vehicles count but will not record the composition of traffic (9 the video-gram metric method). It is a video shoot conducted focusing the traffic moving along the selected road and later traffic volume and its composition can be evaluated. This method is used for traffic speed, data collection [9].

Traffic speed is the second macroscopic traffic flow characteristic that describing the state of the traffic stream and is defined as the rate of motion in distance per unit time and travel time is the time taken to traverse a defined section of roadway. Traffic speed is influence by volume, capacity, design, weather condition, traffic control devices, posted speed limit, and individual driver preference and it has 2 categories. Design speed is a selected speed used to determine the various geometric design features of the roadway. It is important to design facilities with all elements in balance and consistent with an appropriate design speed. Design elements such as sight distance, vertical and horizontal alignment, lane and shoulder widths, roadside clearances, super elevation have been influenced by design speed. Selection of design speed for a given functionally classified roadway has been influenced primarily by the character of the terrain, economic consideration, extent of roadside development, and highway type [10].

Density is the third measure of traffic flow characteristics, which is defined as the number of vehicles occupying a given length of highway or lane, expressed as vehicles per mile (veh $mi^{-1}$) or vehicles per mile per lane. Density is difficult to measure directly from elevated vantage points from which the highway section under study and may be observed is required, often computed from flow rate and speed measurements. However, it is the most important of the 3 primary traffic stream parameters, because it is the measure directly related to traffic demand [7].

Consequently, road traffic flows are composed of drivers associated with individual vehicles, each of them having its own characteristics. These characteristics are called microscopic when a traffic flow is considered as being composed of such a stream of vehicles. The dynamical aspects of these traffic flows are formed by underlying interactions between the drivers of the vehicles. These are largely determined by the behaviour of each driver, as well as the physical characteristics of the vehicles [11]. Provides that the process of participating in traffic flow is heavily based on the behavioural aspects associated with human drivers, it would seem important to include these human factors into modelling equations. However, this leads to a severe increase in complexity, which is not always the desired artifact. [7] Reported that microscopic measures are useful for many traffic analyses purposes, because headway may obtain for every pair of vehicles. Microscopic measures also allow various vehicles type to be isolated in the traffic stream. The passenger car has flows and densities be derived from isolating spacing and headway for pairs of passenger cars following each other. Heavy vehicles are could be similarly isolated and studied for specific characteristics.

### Urban street facilities

Urban street facilities describe an integrated multimodal methodology for evaluating the quality of service provided for road users travelling along an urban street. An urban street is unique among road types because it typically serves multiple travel modes. Four, common travel mode of urban streets includes automobile, pedestrian, bicycle and transit [12]. Travelers associated with each of these modes use different criteria to evaluate the service provided to them when they travel along an urban street. For purpose of analysis, urban street is separate into individual elements that are physically adjacent and operate as a single entity. For serving travellers, 2 elements commonly found on urban street systems, which are points and links. A point represents the boundary between links and is usually represented by intersection or ramp terminal. Link represents a length of roadway between 2 points and its boundary intersection is referred to as a segment. An urban street facility is a length off road-way that is composed of contiguous urban street segments [12].

## Materials and methods

Assortment of data and analysis focused on 3 midblock for evaluating flow parameters within 4 sub-cities. The data taken were for 3 weekdays and 1 weekend, which are Monday, Wednesday, Thursday and Saturday. The days were taken based on several field visits and evaluation of the thematic area that means the first and third stated days were local market day whereas the second and last stated days were representative to observe the flow characteristics. For analysis, Thursday was taken as representative and design day from 4 designated days, due to the efficient number of traffic, more inclusive for the study of traffic flow parameters and mixed type of traffic observed.

### Assortment of data

The collected data were more of primary data that are a practical gathering of the parameter done on file for the road corridors in a different location with considerable procedures and guidelines. The design methodology of the work is shown in **Figure 2**.

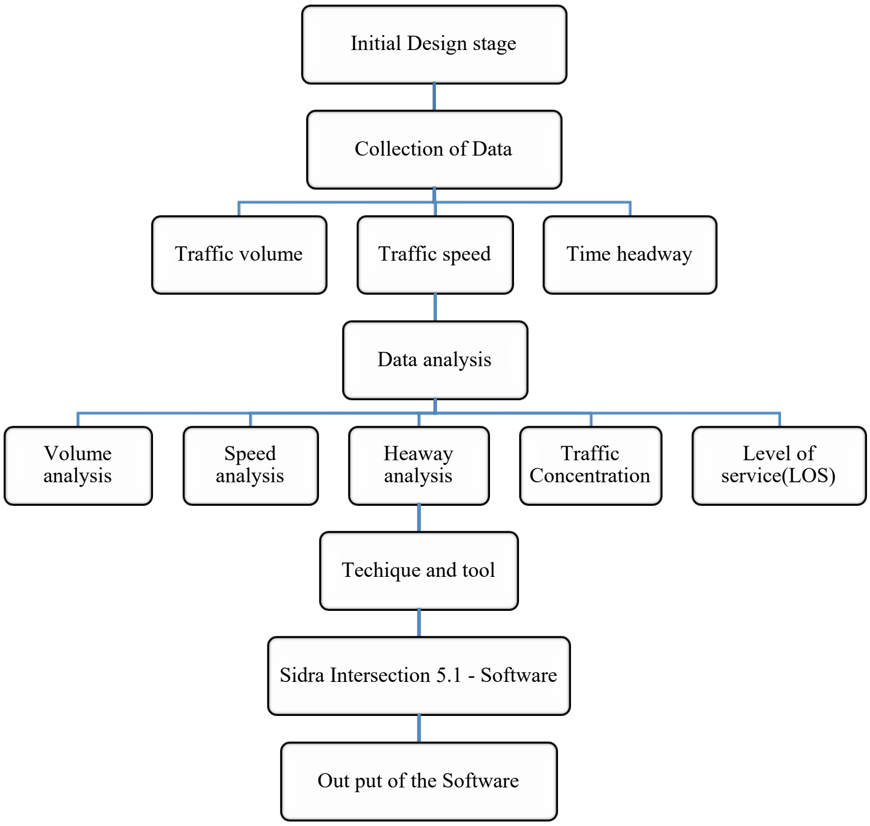


**Figure 2** Design methodology.

Traffic volume, traffic speed, time headway and road width were collected for selected road corridors in different sub-city within Hawassa city. The tools that were adopted for the collection of filed data were data collection format, plastic tape, chuck, digital camera and stopwatch respectively. Sidra Intersection 5.1 tool is used for analysis. The location detail for all road sections were described in **Table 1** below.

**Table 1** Location detail for road sections.

| S.No | Name of locations | Designation | Road width(m) |
|---|---|---|---|
| 1 | Alamura-SNNPR Health Bureau | Road-I | 11.6 |
| 2 | South star-Godegohada | Road-II | 9.4 |
| 3 | Mobile-Areb sefer | Road-III | 11.0 |

## Results and discussion

### Alamura-SNNPR Health Bureau midblock

Alamura-SNNPR Health Bureau road section (R-I) is considered and the outputs are presented as movement summary, lane summary, flow displays and movement displays. The demand of flow, degree of saturation, practical spare capacity, and level of service (LOS) shows major changes both for current and future condition. Movement and lane summary are described in **Table 2** and **3** below. The movement summary shows that demand of flow for both directions separately are 1064 veh $h^{-1}$ and 516 veh $h^{-1}$ in Alamura and SNNPR Health Bureau, respectively. The degree of saturation is 0.748 for Alamura direction and 0.266 for SNNPR Health Bureau direction. The average travel speed for all vehicles for this midblock is 29.9 km $h^{-1}$ shown below in **Table 2**.

**Table 2** Movement summary for Alamura-SNNPR Health Bureau Midblock.

| Mov ID | Turn | Demand flow (veh/h) | HV (%) | Deg.Satn (v/c) | delay (s) | LOS | travel speed (km.h) |
|---|---|---|---|---|---|---|---|
| **Movement performance-vehicles** | | | | | | | |
| **East: Alamura** | | | | | | | |
| R-I | T | 1064 | 0.8 | 0.748 | 7.9 | C | 23.1 |
| Approach | | 1064 | 0.8 | 0.748 | 7.9 | C | 23.1 |
| **West: SNNPR Health Bureau** | | | | | | | |
| r-I | T | 516 | 1.1 | 0.266 | 0.0 | | 54.8 |
| Approach | | 516 | 1.1 | 0.266 | 0.0 | | 54.8 |
| All vehicles | | 1580 | 0.9 | 0.748 | 5.4 | C | 29.9 |

Average travel speed is the interrupted travel speed of all vehicles with including all kinds of delay, which is medium for this midblock. The average travel speed value depends on the total travel distance, average delay and cruise speed of the section. Cruise speed is the average speed which was taken without considering any kind of delay when measuring on spot and this value for both directions is 47.37 km $h^{-1}$ and 54.83 km $h^{-1}$, respectively. The (LOS) of this midblock based on the performance measures is LOS C.

In the lane summary report displayed in **Table 3** the capacity is mention based on the degree of saturation and adjusting the basic saturation flow for heavy vehicles, demand of flow and turning vehicle effects. Meanwhile, inflow displays, the number of heavy vehicles in percent from total demand of flow are 0.8 and 1.1 % for each direction in current condition.

**Table 3** Lane summary for Alamura-SNNPR Health Bureau midblock.

| Lane use and performance | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mov ID** | **Demand flow(veh/h)** | | | | **HV** | **Deg.Satn** | **Cap** |
| | **L** | **T** | **R** | **Total** | **(%)** | **(v/c)** | **(veh/h)** |
| **East: Alamura** | | | | | | | |
| Lane-1 | 0 | 1064 | 0 | 1064 | 0.8 | 0.748 | 1422 |
| Approach | 0 | 1064 | 0 | 1064 | 0.8 | 0.748 | |
| **West: SNNPR Health Bureau** | | | | | | | |
| Lane-2 | 0 | 516 | 0 | 516 | 1.1 | 0.266 | 1937 |
| Approach | 0 | 516 | 0 | 516 | 1.1 | 0.266 | |
| Intersection | | 1580 | | | 0.9 | 0.748 | |

The other parameter is practical spare capacity, which is the increment in demand flow rate in percent required to equalize the calculated degree of saturation to practical degree of saturation, and for this midblock in movement displays are 6.9 and 200.2 % for Alamura and SNNPR Health Bureau directions respectively. The future condition of Alamura-SNNPR Health Bureau midblock is analyzed from the current base with a constant growth rate for the coming 6 years.

In **Figure 3** below 5 parameters are used for description, this is the demand of flow, average travel speed, degree of saturation, practical spare capacity, and total effective capacity. The average travel speed with including all kinds of delays and became in the chart on current condition is 29.9 km $h^{-1}$ and in the future, this value became 25.83 km $h^{-1}$ and resulted in decline in average travel speed in this midblock is by 13.61 %. The second parameter used for this analysis is the degree of saturation and display increment by 18.31 % from the base condition and which is not a significant variation. Both the practical spare capacity and effective capacity also display declines by 249.13 and 5.23 % from current condition and from this, the increase in demand of flow to equalize the degree of saturation shows more than 200 % increment, which is a significant value.

The effective capacity, which is the ratio of the total demand of flow to the degree of saturation of the intersection. Which is minimum in the condition that is less than 10 %. The demand of flow shows persistent increment (which is 2 % per year) in each year due to the growth rate value for all midblock are constant then at the start of 6-year, the flow of demand in this midblock became 12 % increase from the base. The performance of the route in terms of (LOS) in the future conditions in this midblock goes to LOS D.

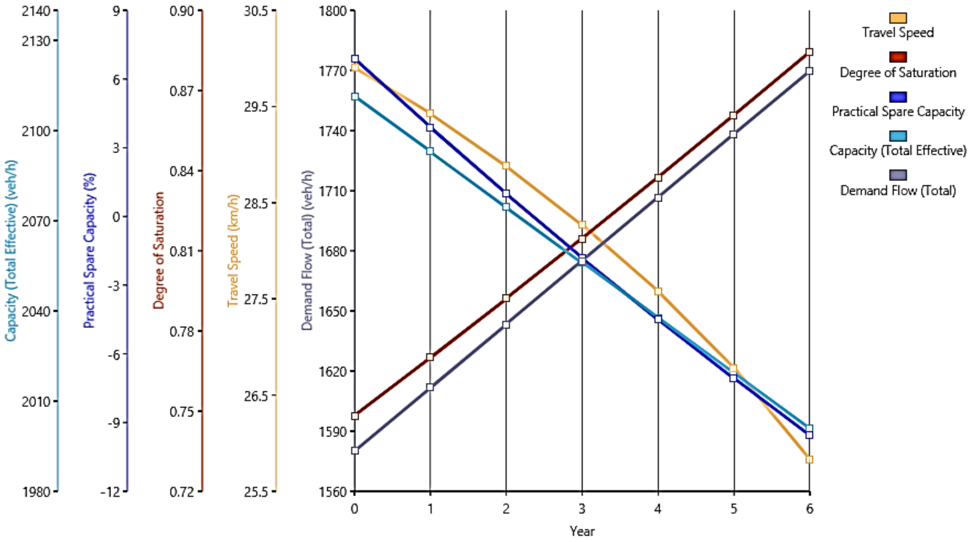


**Figure 3** Future condition analysis for Alamura - SNNPR Health Bureau midblock.

**South star - Godegohada midblock**

South star - Godegohada midblock (R-II) evaluated and the outputs are present as movement summary, lane summary, flow displays, and movement displays. The demand of flow, degree of saturation, average travel speed, practical spare capacity, and LOS shows major changes both for current and future condition. The movement summary and lane summary are designate in **Table 4** and **5** below separately. The movement summary shows that demand of flow is 1368 veh $h^{-1}$ in the south star direction and 845 veh $h^{-1}$ in the Godegohada direction, respectively. Again, the degree of saturation was 0.915 and 0.620 for each direction separately. The overall level of service of this midblock is LOS E which the capacity of the road less able to support the demand of flows, but with considerations. The average travel speed for all vehicles for this midblock is 19.5 km $h^{-1}$ shown below in **Table 5** and the cruise speeds in the South star and Godegohada directions are 40.01 and 52.51 km $h^{-1}$, respectively.

**Table 4** Movement summary for South star-Godegohada midblock.

| Movement performance-vehicles | | | | | | |
|---|---|---|---|---|---|---|
| **Mov ID Turn** | **Demand flow (veh/h)** | **HV (%)** | **Deg.Satn (v/c)** | **delay (s)** | **LOS** | **travel speed (km.h)** |
| **South: Godegohada** | | | | | | |
| r-II T | 845 | 2.3 | 0.620 | 6.2 | B | 27.6 |
| Approach | 845 | 2.3 | 0.620 | 6.2 | B | 27.6 |
| **North: South star** | | | | | | |
| R-II T | 1368 | 3.7 | 0.915 | 11.2 | E | 14.9 |
| Approach | 1368 | 3.7 | 0.915 | 11.2 | E | 14.9 |
| All vehicles | 2213 | 3.2 | 0.915 | 9.5 | E | 19.5 |

In the lane, summary report in **Table 5** below which capacity is mention based on the degree of saturation and adjusting the basic saturation flow for heavy vehicles, demand of flows, and turning vehicle effects. Inflow displays, the numbers of heavy vehicles in percent from total demand of flow are 3.7 % in South star and 2.3 % in Godegohada directions in current condition.

**Table 5** Lane summary for South star - Godegohada midblock.

| Lane use and performance | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mov ID** | **Demand flow(veh/h)** | | | | **HV** | **Deg.Satn** | **Cap** |
| | **L** | **T** | **R** | **Total** | **(%)** | **(v/c)** | **(veh/h)** |
| **South: Godegohada** | | | | | | | |
| Lane 1 | 0 | 845 | 0 | 845 | 2.3 | 0.620 | 1363 |
| Approach | 0 | 845 | 0 | 845 | 2.3 | 0.620 | |
| **North: South star** | | | | | | | |
| Lane 2 | 0 | 1368 | 0 | 1368 | 3.7 | 0.915 | 1495 |
| Approach | 0 | 1368 | 0 | 1368 | 3.7 | 0.915 | |
| Intersection | | 2213 | | | 3.2 | 0.915 | |

The practical spare capacity, which is the increment in demand flow rate for this midblock in movement displays, are −12.5 and 29.0 % in South star and Godegohada directions, respectively. The negative value in practical spare capacity shows that demand of flow is more than the capacity of in a given section of the road (demand of flow was higher than capacity) and in this South star direction displays significant increment in the demand of flow. The future condition of South star-Godegohada midblock is evaluated with a constant growth rate.

Five parameters are adopted for description in **Figure 4** below in detail and average travel speed is stated in the chart on current condition it is 19.5 km $h^{-1}$ and for future condition became 4.3 km $h^{-1}$ that displays significant dropdown 77.95 % from the base. Similarly, the degree of saturation for current and future conditions are 0.915 and 1.124, respectively and show increment by 22.84 % and practical spare capacity displays increment to 130.4 % is observed that actual demand of flow are exceeding the carrying capacity of this route gradually and the total effective capacity also shows declined by 8.87 % from the existing condition. The demand of flow also shows an upgrade by 12 % at the start of 6 years from the base condition. Finally, the overall performance of midblock in terms of the level of service (LOS) in future conditions became LOS F.

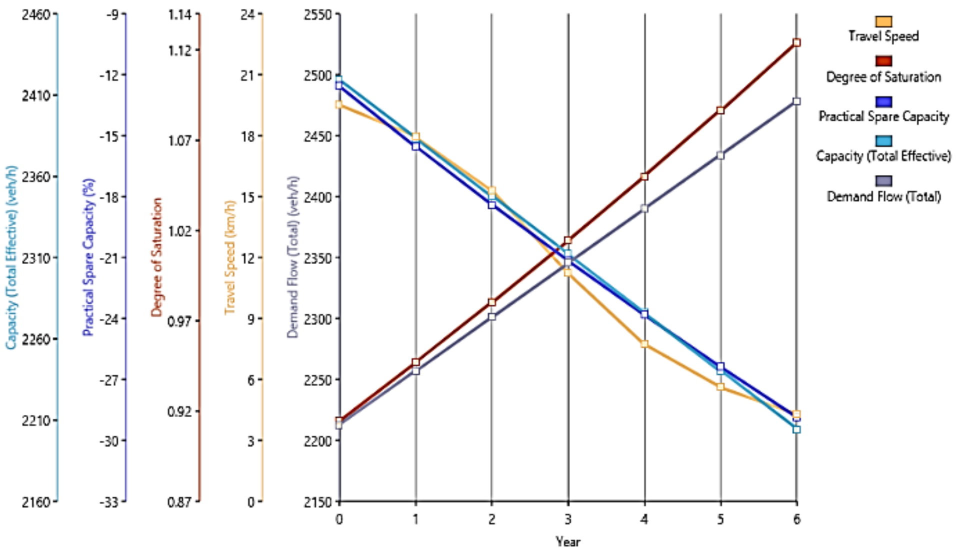


**Figure 4** Future condition analysis for South star - Godegohada midblock.

**Mobile-Areb sefer midblock**

Mobile-Areb sefer road section (R-III) is evaluated and the outputs are précised as movement summary, lane summary, movement displays, and flow displays. Significant changes are observed in demand of flows, Average travel speed, degree of saturation, and practical spare capacity both for current and future conditions. The movement summary and lane summary are described below in **Table 6** and Table respectively. The movement summary of this road section shows that the demand of flow is 1727 veh $h^{-1}$ for Mobile direction and 1364 veh $h^{-1}$ for Areb sefer direction on current condition. Again, the degrees of saturation are 1.765 and 0.716 for each direction. This value shows that the demand for flow was increasing throughout the year and the capacity declines to support this demand of flow, which has a direct impact on the level of service and performance of this midblock.

**Table 6** Movement summary for mobile - Areb sefer midblock.

| Movement performance-vehicles | | | | | | |
|---|---|---|---|---|---|---|
| **Mov Id Turn** | **demand flow (veh/h)** | **HV (%)** | **deg.Satn (v/c)** | **delay (s)** | **Los** | **travel speed (km.h)** |
| **South: Mobile** | | | | | | |
| R-III T | 1727 | 3.6 | 1.765 | 693.5 | F | 0.4 |
| approach | 1727 | 3.6 | 1.765 | 693.5 | F | 0.4 |
| **North: Areb sefer** | | | | | | |
| r-III T | 1364 | 3.6 | 0.716 | 0.0 | C | 38.4 |
| approach | 1364 | 3.6 | 0.716 | 0.0 | C | 38.4 |
| vehicles | 3092 | 3.6 | 1.765 | 387.5 | F | 0.7 |

Cruise speed is the average speed which is taken without considering any kind of delay when measuring on spot and this value for both directions are 37.33 and 38.40 $h^{-1}$ in Mobile and Areb sefer directions respectively. The overall LOS of this road section based on the performance measures is LOS F. In the lane, summary report displayed in **Table 7** that capacity is mention based on the degree of saturation and adjusting the basic saturation flow for heavy vehicles, demand of flow, and turning vehicle effects. Meanwhile, inflow displays, the number of heavy vehicles in percent from total demand of flow is 3.6 % for each direction in current condition.

**Table 7** Lane summary for Mobile-Areb sefer midblock.

| Lane use and performance | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Mov ID** | **demand flow(veh/h) L** | **T** | **R** | **Total** | **HV (%)** | **Deg.Sat (v/c)** | **Cap (veh/h)** |
| **South: Mobile** | | | | | | | |
| Lane 1 | 0 | 1727 | 0 | 1727 | 3.6 | 1.765 | 981 |
| approach | 0 | 1727 | 0 | 1727 | 3.6 | 1.765 | |
| **North: Areb sefer** | | | | | | | |
| Lane 2 | 0 | 1364 | 0 | 1364 | 3.6 | 0.716 | 1906 |
| approach | 0 | 1364 | 0 | 1364 | 3.6 | 0.716 | |
| intersection | | 3092 | | | 3.6 | 1.765 | |

The other parameter is a practical spare capacity which is the increment in demand flow rate in percent required to equalize the calculated degree of saturation to practical degree of saturation and for this road section in movement displays are −54.5 and 11.8 % for Mobile and Areb sefer direction, respectively. The negative value in practical spare capacity shows the increment of demand of flow compared with the capacity of the route.

The future condition of Mobile - Areb sefer road section was analyzed from the current base with a constant growth rate for the coming 6 years. In **Figure 5** below, 5 parameters are used for description; these are average travel speed, degree of saturation, practical spare capacity, total effective capacity, and demand flow. The average travel speed is mention in the chart on the current condition the value is 0.716 km $h^{-1}$ and for future condition, the value is 0.338 km $h^{-1}$, and the result dropdown by 52.80 % from base. Similarly, degree of saturation for future condition is 2.64 and shows increment by 50.0 % and practical spare capacity display increment by 27.88 %. The total effective capacity of this midblock shows decline to 21.08 % from current condition compare with the existing condition and demand of flow also display increment to 12 % in future condition.

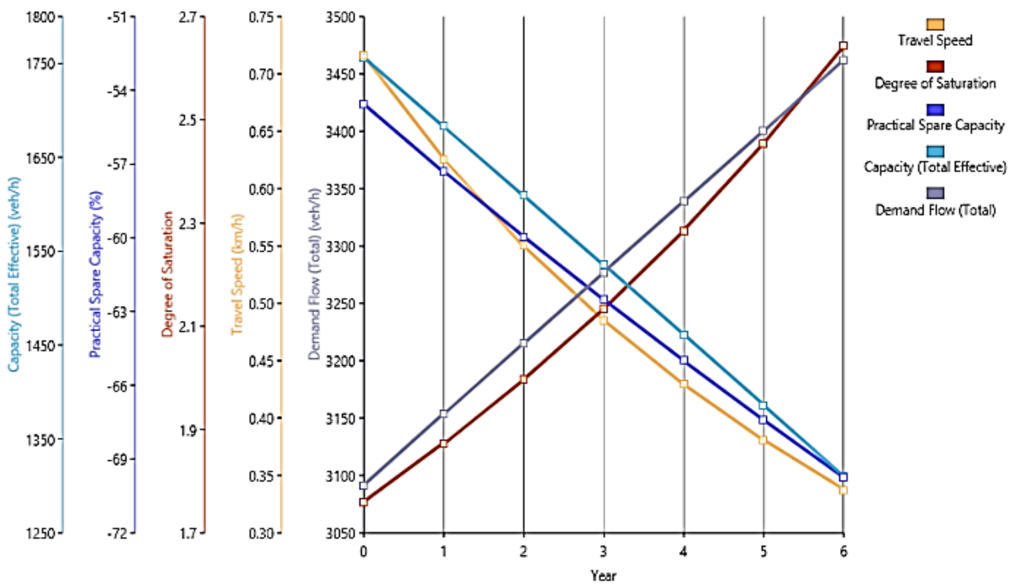


**Figure 5** Future condition analysis for mobile - Areb sefer midblock.

**Summary of the output of Sidra intersection 5.1 software**

In average travel speed, variations are perceiving both in current and future conditions for Mobile-Areb sefer to Alamura-SNNPR Health Bureau 2-way midblock. Compare to the other 2-way road section high value in average travel speed is observed in Alamura-SNNPR Health Bureau road section because this section has a smaller number of movements of flow, mixed type of traffic, and wider approach road width along the corridor. In future conditions, the South star-Godegohada midblock shows a high deviation in travel speed, which is 25.15 % extra than Mobile-Areb sefer and 64.34 % than Alamura-SNNPR Health Bureau midblock due to the result of average delay and cruise speed of the sections.

In practical spare capacity, from all road sections, Mobile-Areb sefer and South star-Godegohada are negative which means that the demand of flow in this corridor is exceeding the traffic flow carrying capacity. In future conditions, the roads Mobile-Areb sefer requires less in demand flow rate to equalize this degree of saturation to practical degree of saturation that means 102.52 % lower than South star-Godegohada and 221.25 % than Alamura-SNNPR Health Bureau road sections.

In degree of saturation, again high variations are observed between 0.73 - 1.76 values for all midblock. Both South star-Godegohada and Mobile-Areb sefer results that the capacity would decline to support incoming in demand of flows from both directions due to they have higher value of the degree of saturation. The increment in degree of saturation nearer to 1 and above results declining the capacity of the section. Again, Alamura-SNNPR Health Bureau almost has the same value in the degree of saturation, which is moderate. In future conditions, Mobile-Areb sefer road section displays a half - percent increment in degree of saturation, which is 27.16 % more than South star-Godegohada, and 31.69 % than Alamura-SNNPR Health Bureau road sections.

In total effective capacity, based on adjusting total demand of flow and degree of saturation are declined for all 2-way road sections gradually. In terms of total effective capacity, Mobile-Areb sefer road section is more 2.37 times than South star-Godegohada and 4.03 times than Alamura-SNNPR Health Bureau, road sections will decline in future condition.

In demand of flow, variation from section to section is observed in 2-way roads due to location of section, surrounding activities, condition of the road, configuration in traffic, and pattern of traffic movement along this corridor. Less number of volumes of traffic is observed in Alamura-SNNPR Health Bureau section than in the others section at peak time.

Average delay, the additional travel time experienced by a vehicle with reference to a base travel time for all road sections is observed but not highly influenced the movement of traffic flow in urban road facilities. Delay is not incorporated in this analysis for intersection level of service (LOS) and major road approach level of service (LOS) because in free-way roads the average delay is not a good LOS measure due to 0 delays associated with major road lanes and will alter the out of the analysis. Minimum average delay values are displayed in all midblock both in current and future conditions except in Mobile-Areb sefer road section. In overall performance, all midblock are evaluated in terms of the level of service (LOS) which displays change both in existing and future conditions.

Summary for all midblock in current condition (CC) and future condition (FC) are described in **Table 8** below.

**Table 8** Summary for all route in current and future condition.

| Midblock | .travel speed(km $h^{-1}$) | | Degree .satu(v/c) | | Practical spare capacity (%) | |
|---|---|---|---|---|---|---|
| | CC | FC | CC | FC | CC | FC |
| Road-I | 29.9 | 25.83 | 0.75 | 0.88 | 6.9 | −9.6 |
| Road-II | 19.5 | 4.3 | 0.915 | 1.12 | −12.5 | −28.8 |
| Road-III | 0.72 | 0.34 | 1.76 | 2.64 | −54.5 | −69.7 |

| Midblock | effective capacity (veh $h^{-1}$) | | Demand of flow(veh $h^{-1}$) | | LOS | |
|---|---|---|---|---|---|---|
| | CC | FC | CC | FC | CC | FC |
| Road-I | 2111.4 | 2000.9 | 1580.2 | 1769.8 | C | D |
| Road-II | 2419.1 | 2204.4 | 2212.9 | 2478.5 | E | F |
| Road-III | 1756.4 | 1386 | 3091.5 | 3462.5 | F | F |

## Conclusions

Based on the analysis done in all midblock the following deduction is outlined, at peak time the traffic flow rate in both directions is 1528, 2212 and 3092 veh $h^{-1}$ for Alamura-SNNPR Health Bureau, South star-Godegohada and Mobile-Areb sefer midblock, respectively. In Mobile-Areb sefer, the flow rate is 2 times exceeding than Alamura-SNNPR Heath Bureau midblock and again, almost 1.4 times more than the South star-Godegohada midblock are observe. The effects of heavy vehicles (HV) on their surrounding traffic are greater than passenger cars and have the potential to have a substantial impact on macroscopic and microscopic traffic flow characteristics. Because of the interference effect, they have on surrounding motorized vehicles and their percentage on average is 4.2 % in all midblock at existing condition and displays increment in the future condition. The output of the Sidra Intersection 5.1 indicates that all parameters which are operating speed, flow rate, and percent of heavy vehicles have an impact on their serviceability, to entertain their design speed, manoeuvring prospect of drivers, capacity and performance of these roads in terms of the level of service (LOS). Meanwhile, the level of service (LOS) determined in manual techniques and using Sidra Intersection 5.1 tool result no significant variations are observed for all midblock. Furthermore, all midblock in future conditions are studied and the result indicates that average travel speed, degree of saturation, practical spare capacity, demand of flow, and LOS have major changes both in current and future conditions. This road in terms of capacity also shows the change in 5.23, 8.87

and 21.08 % for Alamura-SNNPR Health Bureau, South star-Godegohada and Mobile-Areb sefer midblock are declines in the future condition within the design period. This all considerations mentioned above have a major impact on the normal functioning of this road system. It is possible to accomplish that, this midblock is a proper and major task to analyse in the service and operation period to evaluate their status in current conditions with major performance measures and advancement and to check their enactment in future using tools of current situations.

## References

[1] VT Arasan and RZ Koshy. Methodology for modeling highly heterogeneous traffic flow. *J. Transport. Eng.* 2005; **131**, 544-51.
[2] C Jilin, H Zhejiang and Q Shandong. *Analysis of traffic flow speed-density relation model characteristics.* Vol VIII. China, 2014, p.104.
[3] JC Oppenlander and J Baerwald. *General traffic characteristics.* Vol IV. New Jersey, 1976.
[4] L Elefteriadou. *An Introduction to traffic flow theory.* Springer, Florida, 2014, p.141.
[5] CF Daganzo. *Fundamental of transportation and traffic operations*. Pergamon, Oxford, 1997, p. 67.
[6] M Rogers. *Highway engineering*. Vol I. TJ International Ltd, Cornwall, 2003, p. 73.
[7] RP Roess, ES Prassas and WR Mcshane. *Traffic engineering*. Pearson Education Inc, New Jersey, 2004, p. 114.
[8] National Research Council and Transportation Research Board. *Highway capacity manual*. Transportation Research Board, Washington DC, 2000, p. 8-12.
[9] Ministry of Water and Transport Department of Botswana. *Traffic data collection and analysis.* Ministry of Water and Transport Department of Botswana, Gaborone, 2004.
[10] MA Marek. *Roadway design manual*. Texas Department of Transportation, Texas, 2010, p. 34.
[11] S Maerivoe and BLRD Moor. *Traffic flow theory*. Vol I. Katholieke Universiteit, Leuven, 2008, p. 2.
[12] National Research Council and Transportation Research Board. *Highway capacity manual*. Transportation Research Board, Washington DC, 2010, p. 16-8.