5.3 Tazara Intersection

The previous intersection review has identified Tazara Intersection as being a priority location. This subsection addresses this location in greater detail.

5.3.1 Orientation

Located in the southwestern part of the city, Tazara Intersection accommodates two major trunk roads (Nyerere Road and Nelson Mandela Road), each of which carry considerable traffic volume (**Figure 5.3.1**).

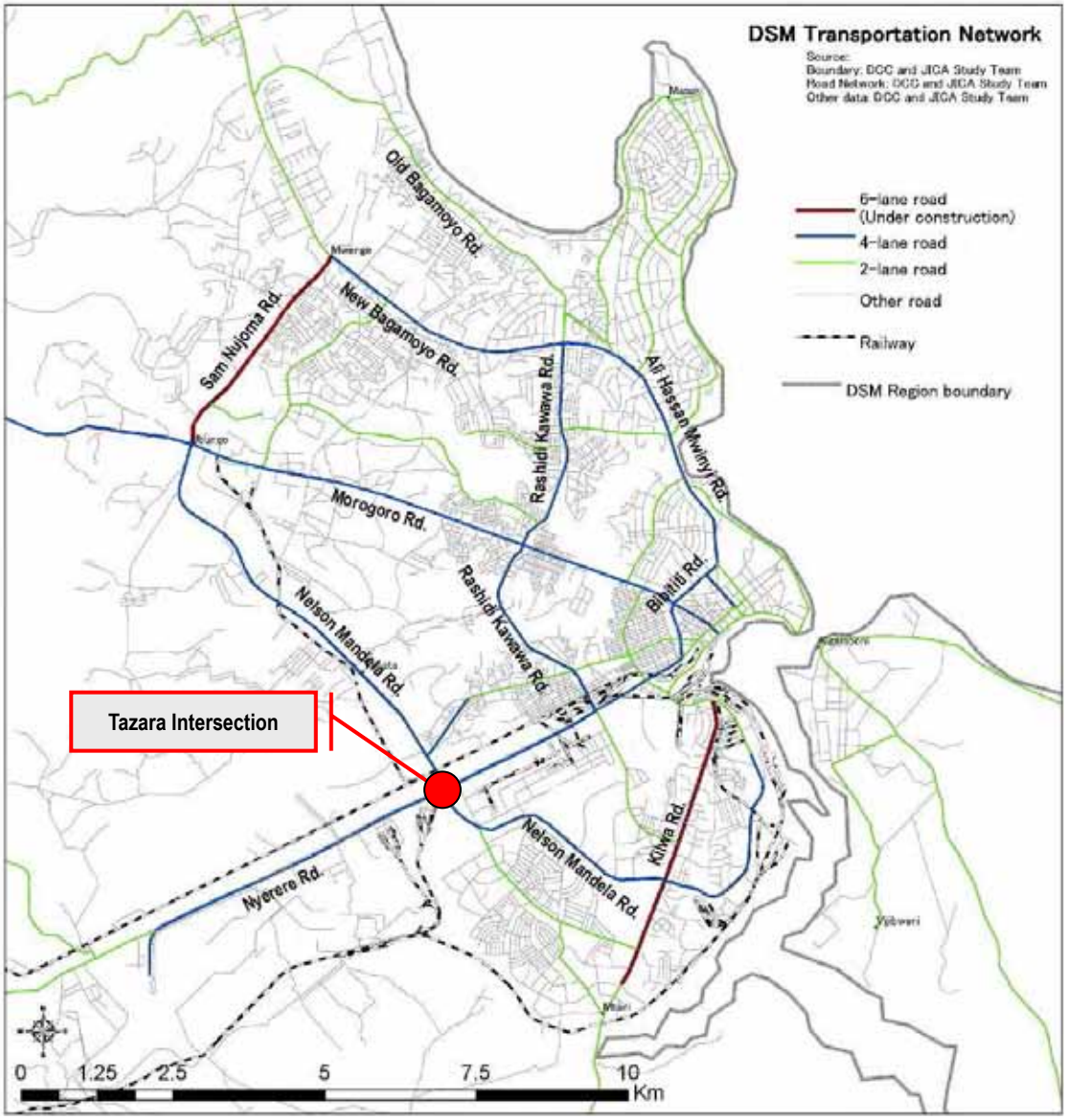


Figure 5.3.1 Tazara Intersection Location

Both facilities feature four-lane cross-sections, with right-turn bays provided on all approaches. Left-turn slip-ramps exist in all four quadrants. Intersection control is via a traffic signal based on a 120 second cycle or, during peak demand periods, intermittent police intervention (**Figure 5.3.2**).

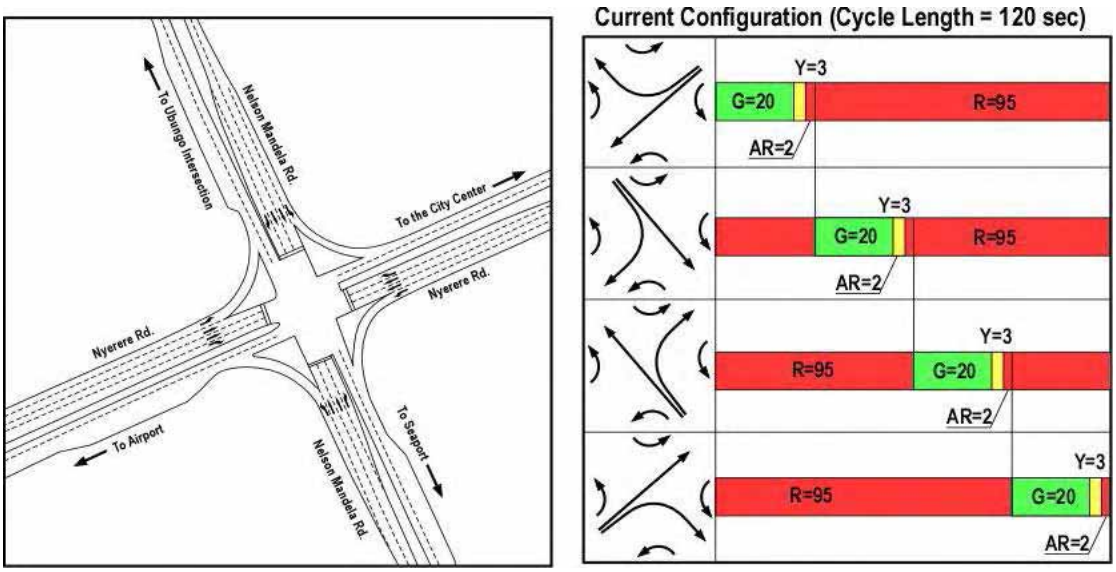


Figure 5.3.2 Current Layout and Signal Control at Tazara Intersection

The roads fulfill a variety of functions:

- Nyerere International Airport lies west of the junction; Nyerere Road is the only major road providing direct access to the airport. While the actual traffic volume to/from the airport is, vis-à-vis the daily metropolitan demand, modest, Nyerere Road is the gateway to Tanzania for many foreign visitors and dignitaries. The massive current congestion at Tazara Intersection is not conducive to forming an "initial positive image".
- Nyerere Road is flanked almost continuously by industrial activities and various companies between approximately the airport and Rashidi Kawawa Road. Thus, in addition to serving as a gateway road to central Dar es Salaam, Nyerere Road also accommodates considerable activity by light (2 or 3 axle) and heavy (more that 3 axle) commercial vehicles.
- The importance of the Nelson Mandela Road corridor to seaport cargo movement is, as already noted in the previous Chapter 3, pronounced. The *Cargo Transport Survey* conducted by the Study Team during June, 2007, queried drivers at the Dar es Salaam seaport as to a number of indicators including routing preferences: 43 percent (the largest subgroup) indicated that the preferred route of travel to/from the port is along Nelson Mandela Road. It is of further interest to note that the mix of commercial vehicles servicing the seaport consists of near 80 percent having more than three axles (that is, articulated vehicles).
- Tazara rail station is located south of the intersection; however, use is intermittent.
- Residential activity intensifies north and south of the intersection; in particular the Tabata development located to the north along Nelson Mandela Road.

Tazara Intersection is one of the few locations in Dar es Salaam (Ubungo Intersection, refer previous subsection 5.2, being another) where major, multi-lane traffic arteries intersect.

5.3.2 Intersection Sufficiency

An insight regarding facility traffic demand can be gleaned from findings of the Master Plan traffic survey program during which traffic counts, stratified by hour, direction and vehicle type, were collected for 14 or 24 hours at some 30 sites throughout the study area[8]. Year 2007 volume information is therefore available along Nyerere Road about 500 meters west of Tazara Intersection, Nelson Mandela Road some two kilometers north of Tazara Intersection, and peak period turning movement counts at Tazara Intersection proper.

- The Nyerere Road traffic count monitored a total of 28,200 vehicles (total both directions of travel) over a 14 hour weekday period. Of that total, 15,000 (53 percent) were cars and pick ups; 7,200 (26 percent) Dala Dala's, 3,500 trucks (12 percent), 900 (three percent) other buses, and 1,600 (six percent) other vehicles. Highest hourly volume was observed during the hour beginning 1700, when some 2,500 two-directional vehicles passed the count station (**Figure 5.3.3**).

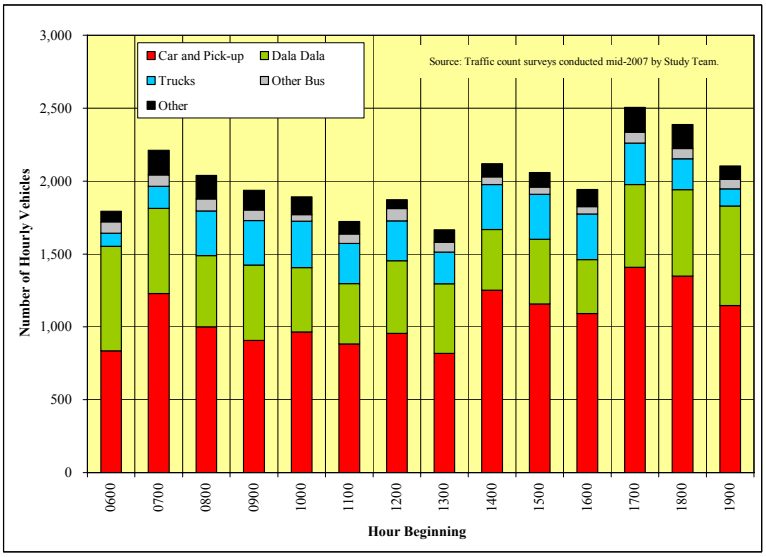


Figure 5.3.3 Hourly Traffic Volume
Nyerere Road West of Tazara Intersection

- The Nelson Mandela Road traffic count monitored a total of 23,900 vehicles (total both directions of travel) over a 14 hour weekday period. Of that total, 13,900 (58 percent) were cars and pick ups; 5,100

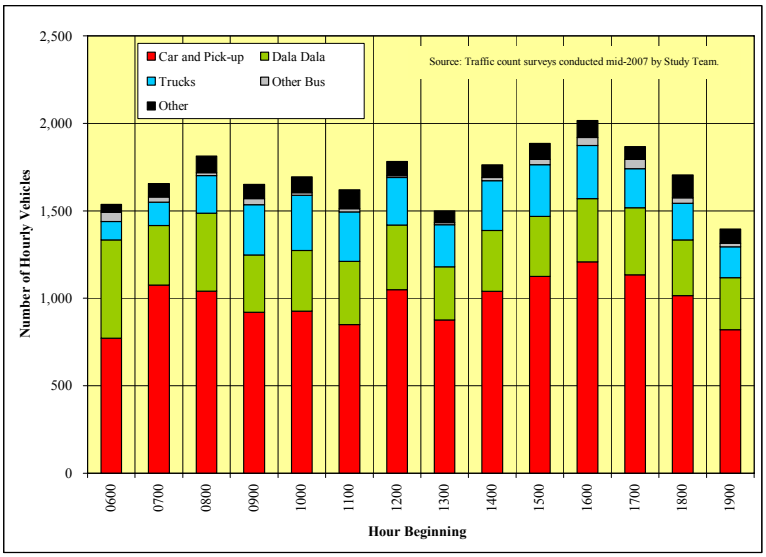


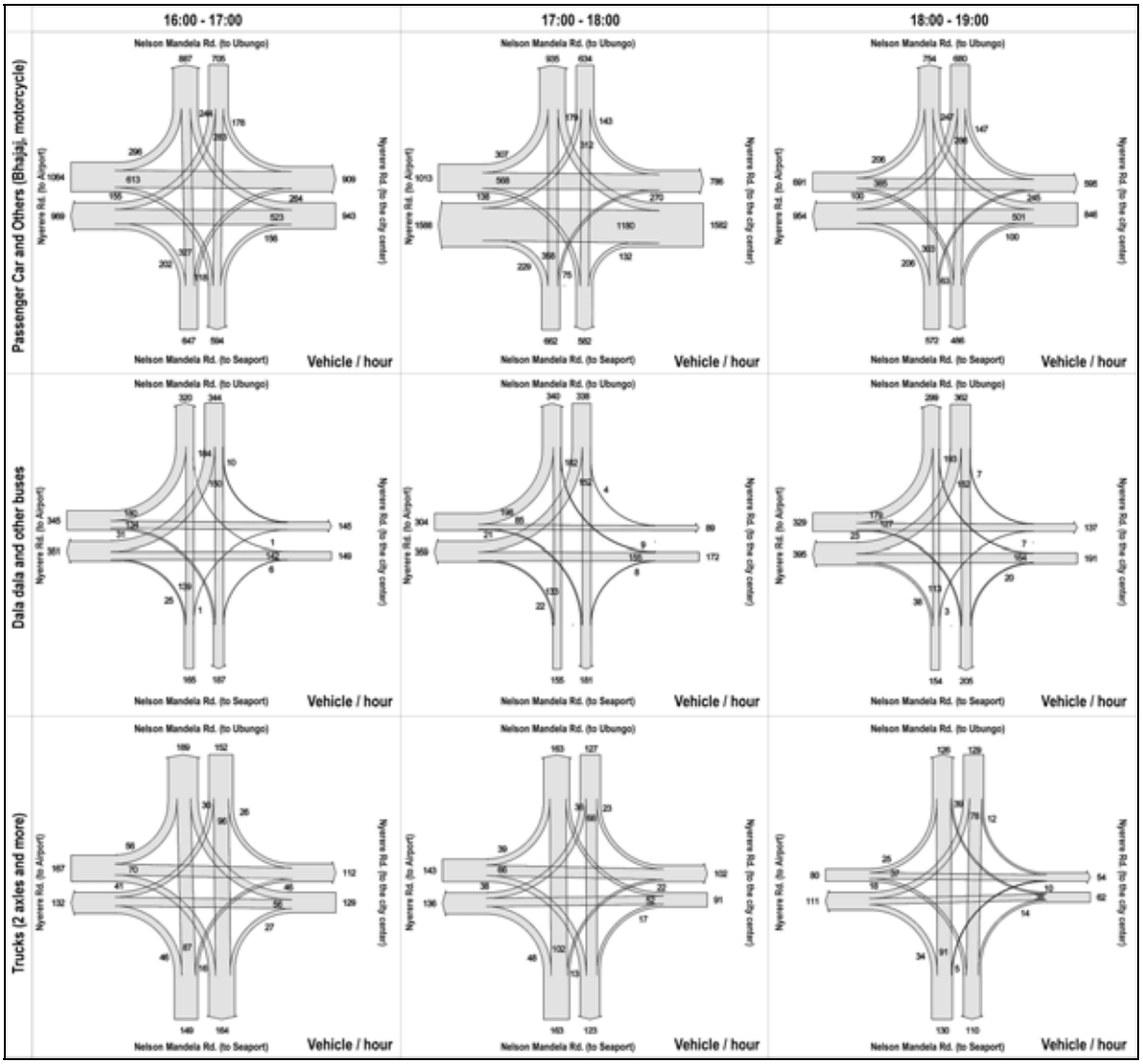
Figure 5.3.4 Hourly Traffic Volume
Nelson Mandela Road North of Tazara Intersection

[8] Refer *Technical Report Volume 6: Dar es Salaam Transport Policy and System Development Master Plan, op. cit. (Chapters 2 and 3)* for further discussion of traffic counting program and results.

(21 percent) Dala Dala's, 3,300 trucks (14 percent), 400 (two percent) other buses, and 1,200 (five percent) other vehicles. Highest hourly volume was observed during the hour beginning 1600, when some 2,000 two-directional vehicles passed the count station (**Figure 5.3.4**).

Both sets of traffic counts confirm that traffic demand is heavy during all hours of the weekday. While some peak period peaking does occur, off-peak hours continue to experience considerable traffic activity.

Turning movements during the critical afternoon peak period were reviewed by vehicle type, and on a clock hour basis (**Figure 5.3.5**). Several conclusions emerge:



Source: JICA Study Team

Figure 5.3.5 Afternoon Peak Period Traffic Volume at Tazara Intersection

- Passenger car demand is focused along Nyerere Road, particularly westbound during the hour beginning 1700 (a total of near 1,600 through cars). The main turning corridors of movement are Nyerere Road (west and east approaches) to/from Nelson Mandela Road (north approach).

- Dala Dala activity mainly follows an axis linking Nyerere Road (west approach) and Nelson Mandela Road (north approach).
- Truck activity is noted on all approaches, with highest recorded volume being the north departure of Nelson Mandela Road. Truck turning volumes are also noted in all quadrants.

The Study Team utilized several approaches to evaluate the operations of the Tazara Intersection environment. These include a volume to capacity review as well as the application of VISSIM micro-simulation software (refer following subsection).

The volume to capacity analysis relies on observed traffic movement volumes and thus represents a snapshot in time. Several conclusions emerge from this review[9] (**Table 5.3.1**):

Table 5.3.1 Tazara Intersection 2007 PM Peak Hour Sufficiency Analysis

Approach	1			2			3			4				
	Nelson Mandera			Nyerere Rd.			Nelson Mandela Rd.			Nyerere Rd.				
	From Ubungo Intersection			From City Center			From Uhasibu			From Airport				
	LT	TH	RT	LT	TH	RT	LT	TH	RT	LT	TH	RT		
Basic value of saturation flow rate	1800	2000	1800	1800	2000	1800	1800	2000	1800	1800	2000	1800		
Number of lane	1	2	1	1	2	1	1	2	1	1	2	1		
Lane width (m)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		
and adjustment factor	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
Share of bus (%)	3.4%	33.8%	43.7%	3.9%	10.5%	3.0%	8.4%	24.7%	0.0%	39.0%	14.2%	11.4%		
and adjustment factor	0.99	0.94	0.92	0.99	0.98	0.99	0.98	0.95	1.00	0.93	0.97	0.98		
Share of truck (%)	12.1%	17.7%	8.2%	13.0%	3.7%	7.0%	17.5%	15.9%	12.2%	8.3%	10.3%	15.8%		
and adjustment factor	0.89	0.85	0.92	0.89	0.96	0.93	0.85	0.86	0.89	0.92	0.91	0.86		
Share of left turn (%)														
and adjustment factor														
Share of right turn (%)														
and adjustment factor														
Saturation flow ratio	1595	3184	1529	1581	3777	1672	1507	3289	1604	1541	3527	1520		
Total traffic volume (vehicle/hour)	174	464	389	154	1282	299	263	554	98	503	662	184		
- Passenger Cars	130	225	187	128	1100	269	195	329	86	265	500	134		
- Dala dala and buses	6	157	170	6	134	9	22	137	0	196	94	21		
- 2 axles Trucks	20	52	27	17	47	14	26	40	12	33	65	26		
- 3 and more axles	1	30	5	3	1	7	20	48	0	9	3	3		
- Others	23	85	16	12	56	3	31	30	6	74	46	12		
Flow ratio	0.109	0.146	0.254	0.097	0.339	0.179	0.175	0.168	0.061	0.326	0.188	0.121	λi	Σλ
Phase ratio phase1		0.146						0.168					0.168	0.941
phase2			0.254						0.061				0.254	
phase3					0.339						0.188		0.339	
phase4						0.179						0.121	0.179	
Required Green phase1		19						19						
phase2			28						28					
phase3					38						38			
phase4						20						20		
Current Cycle Length	120													
Capacity	1,595	504	357	1,581	1,196	279	1,507	521	374	1,541	1,117	253		
V/C	0.123	1.302	1.316	0.117	1.170	1.175	0.230	1.375	0.306	0.418	0.703	0.899		

Source: JICA Study Team

- Peak hour operations are very difficult to quantify given that manual control by traffic police is typically practiced. The volume to capacity review therefore approached the analysis from a slightly different perspective; that is, given observed traffic volumes, signal capabilities and geometric layout, might an optimum operations profile (in terms of intersection saturation) be possible?
- The peak afternoon peak hour (1645-1745 hours based on the highest four consecutive 15 minute count increments during the three hour peak period) catalyzes considerably more negative impact than the morning peak hour (0715-0815 hours). The PM peak hour is shown

[9] Approach and methodology per *Planning and Design of At-grade Intersections*, The Japan Society of Traffic Engineers, 2002.

as achieving an unacceptable saturation rate of 0.9410, one of the highest monitored in the study area.

- Thus, the afternoon peak hour is operating at critical levels with intersection saturation near unity. Particularly critical approaches include Nelson Mandela Road (southbound through and right; northbound through) as well as the westbound approach of Nyerere Road (through and right turn).

5.3.3 Programmed and Anticipated Improvements

Several projects have been proposed and committed which directly impact Tazara Intersection.

- Nelson Mandela Road is being improved, largely within existing alignments. The extent is from vicinity of the seaport to Morogoro Road, or approximately 16 kilometers. The existing multi-lane cross-section will be retained, but considerable enhancements of road surface, drainage and traffic control expected. The project is being sponsored by the European Commission. Completion is expected within approximately two years. Current plans at Tazara Intersection call for implementation of a high-order signal system; however, the Study Team is of the opinion that this may represent only a near to mid-term solution, and that growing traffic volumes will likely overwhelm any at-grade betterment in due course.

  Productive discussions have already been held between representatives of TANROADS, the European Commission, the Study Team and other interested stakeholders. There is growing consensus that there may well be justification for revising the current improvement project by including a flyover at Tazara Intersection.

- The issue of truck routes is becoming increasingly relevant already within the current context. The *Cargo Transport Survey*, as well as other analyses described in the previous Chapter 3, confirmed the importance of Nelson Mandela Road and Nyerere Road as a noted choices as corridor of heavy vehicle travel. Each have important implications for cargo movement by heavy commercial vehicles. Based on these preferences, as well as reviews conducted within the framework of the Master Plan, an "immediate action" truck route was developed (please refer previous Chapter 3, this volume, **Figure 3.6.1**) which includes a circumferential link (the Nelson Mandela Road belt) with radial connectors along main corridors of heavy vehicle activity: to certainly include Nyerere Road and Tazara Intersection.

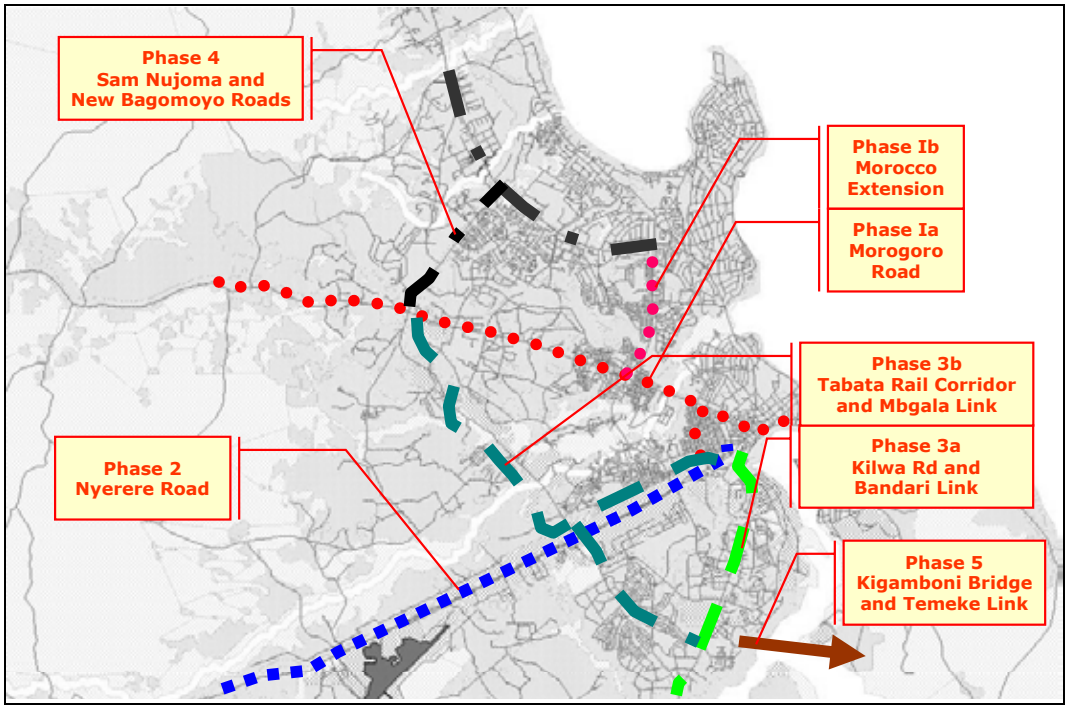
  The truck route network also represents an initial step towards an "inner ring road" circumnavigating the central area of Dar es Salaam. This argues that, should more advanced solutions emerge such as grade separations, that the direction of the separations be structured along the Nelson Mandela Road belt; that is, in support of circumferential routing and the truck route. The alignment of any flyovers along the belt in a consistent circumferential

[10] Guidelines suggest that a ratio of less than 0.85 implies acceptable intersection operation while a ratio of near unity indicates that the intersection is operating at full saturation and likely to experience unstable performance. A ratio in excess of 1.0, to say 1.4 approximately, implies intersection failure.

direction will also preclude "congestion transfer" (that is, speed and capacity benefits gained at a flyover will become liabilities at the next signalized junction encountered). The circumferential flyover alignment is also preferred to radial-direction flyovers in that the latter approach simply encourages more to/from CBD traffic; this will increasingly, and considerably, burden the numerous traffic signals located within the core area.

- The BRT bus network, to include both the on-going implementation of the Phase I system, as well as further build-out (Phases 2 through 5) proposed by the Study Team is discussed in detail beginning Chapter 10 of this violume. There are two essential considerations: location of BRT busways, consisting of dual median-sited BRT lanes plus stations; and, supporting routes outside of the busway. In the latter case, this includes regular sized buses operating in mixed traffic; thus, from a road operations point of view, do not represent a critical issue. However, the actual location of busways is of considerable interest as these directly impact, both in physical and operational terms, functioning of intersections and road segments.

  The staged busway locations are noted in **Figure 5.3.6**. It is noted that the Nyerere Road BRT system is proposed in the second phase; that is, immediately following implementation of the currently committed Phase I (Morogoro Road) system. The Nyerere Road system will, in the opinion of the Study Team, be realized approximately year 2011.



Source: JICA Study Team

Figure 5.3.6 Master Plan Phased BRT Busway Infrastructure Network

5.3.4 Simulation of Intersection Operations

The VISSIM micro simulation examined two cases of intersection operation; namely, (a) the existing situation, as described in previous subsections; and, (b) a generalized grade separation concept with a

flyover along the Nelson Mandela Road axis.

- **Existing Condition.** The initial simulation relates to current conditions; that is, four phase signal cycle, existing intersection layouts, and observed traffic volumes.

  The volume to capacity review (refer previous section) has already determined that existing PM peak hour conditions are saturated bordering on operational breakdown. The main intent of the VISSIM simulation is to quantify the operational conditions within the intersection as a "beginning point"; that is, benchmark parameters against which the operational conditions of other intersection layouts may be compared.

  The simulation confirms that, over a three hour PM peak period (1600-1900) some 12,900 vehicles pass through the intersection. These travel a total distance of near 29,500 kilometers for an average model boundary condition of 2.3 km per vehicle. The average travel time for passing through the modeled precinct is 3.4 minutes, to include 0.7 minute of delay. The average network speed (that is, for all movements on all approaches through and within the intersection area) was some 42 kilometers per hour (**Table 5.3.2**).

Table 5.3.2 Simulation Quantification: Existing Condition

Parameter	Amount
Number of vehicles processed	12,876
Total distance traveled (km)	29,446
Average travel distance (km/vehicle)	2.3
Total travel time (hours)	719
Average travel time (min/vehicle)	3.4
Average simulation speed (km/hr)	41.6
Total simulation delay (hour)	148
Average delay (min/vehicle)	0.7

Source: JICA Study Team

A further benefit of the simulation is the ability to view, in simulated time, actual conditions of intersection operation. That is, a "snap shot" at a particular time. It is, for example, confirmed by the model that queue build-ups on high-demand approaches degrade intersection operation (**Figure 5.3.7**).

Source: JICA Study Team

Figure 5.3.7 Queue Build-up along Nyerere Road Approaches Simulation of Existing Peak Period Condition

- **Flyover Case.** The second simulation integrates a flyover facility along the Nelson Mandela Road axis (**Figure 5.3.8**).

Source: JICA Study Team

Figure 5.3.8 Flyover Provided for Nelson Mandela Road Simulation of Existing Peak Period Condition

The flyover would carry "through" Nelson Mandela Road traffic in both directions; right and left turn maneuvers would continue to be carried out at-grade. Likewise, for Nyerere Road, all movements would take place at-grade, including the ultimate Phase 2 BRT. Given the removal of north-south through movements, and the requisite reallocation of signal time, considerable reserve cycle time would now be available for allocation to other movements. However, while overall intersection operations are likely to be improved at this particular junction, the solution may in fact catalyze "congestion transfer". This again reinforces the importance of viewing Nelson Mandela Road on a corridor basis, and providing systematic flyovers aligned along the Mandela belt. For example, the Ubungo Intersection discussion is consistent in that regard (refer previous subsection 5.2).

Findings of the micro-simulation confirm considerable benefits. While the average vehicle distance traveled through the modeled area remains identical to the existing case (2.3 kilometers), average travel time has reduced by some 12 percent to 3.0 minutes per vehicle, average simulation speed has increased by roughly 10 percent to near 46 km/hr, and average delay per vehicle has decreased dramatically by some 40 percent to 0.4 minutes per vehicle (**Table 5.3.3**).

Table 5.3.3 Simulation Quantification: Existing Condition and Flyover Case

Parameter	Amount	
	Existing	Flyover Case
Number of vehicles processed	12,876	12,903
Total distance traveled (km)	29,446	30,008
Average travel distance (km/vehicle)	2.3	2.3
Total travel time (hours)	719	656
Average travel time (min/vehicle)	3.4	3.0
Average simulation speed (km/hr)	41.6	45.8
Total simulation delay (hour)	148	84
Average delay (min/vehicle)	0.7	0.4

Source: JICA Study Team

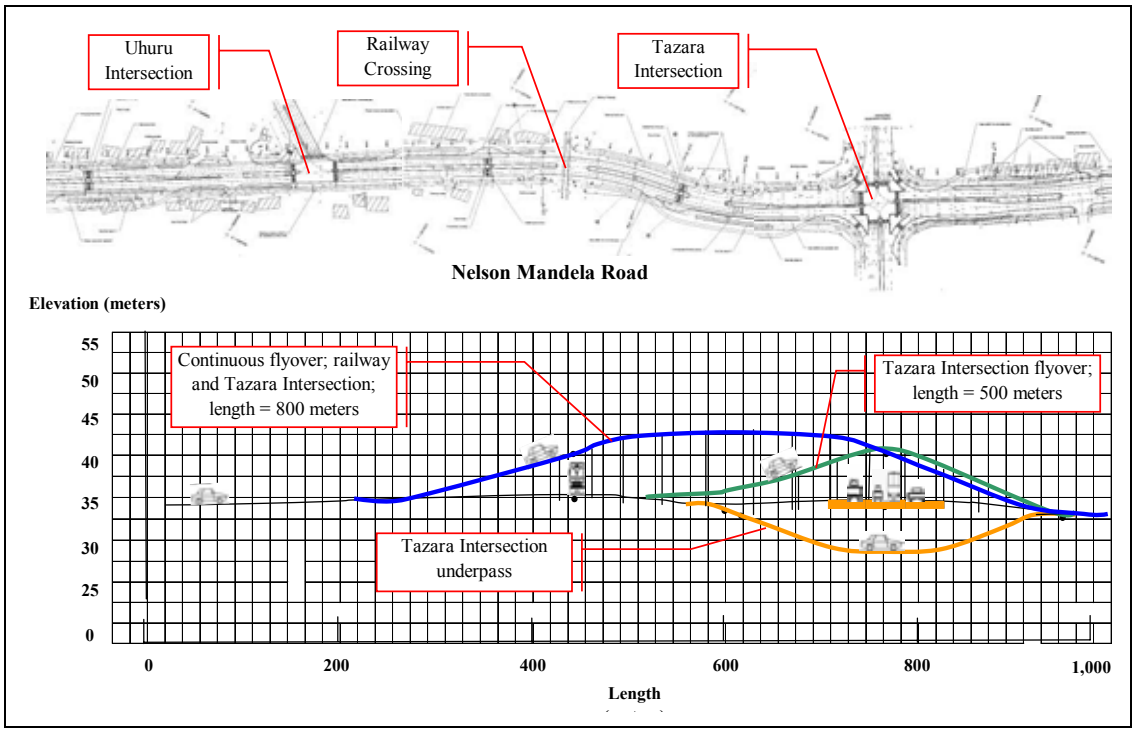
5.3.5 Flyover Options

The physical crossing of Nyerere Road can take several forms; three core choices would exist at initial inspection (**Figure 5.3.9**). These are:

- A continuous flyover of about 800 meters length spanning both Tazara Intersection and the nearby railway tracks. The benefits of such a structure are obvious in that traffic operations will, to certain degrees, no longer be impacted by rail operation. That is, through north-south traffic on Nelson Mandela Road; all turning movements would still occur at grade. However, at present, rail service is very intermittent and does not appear to present a major obstacle to traffic flow other than periodic inconvenience. However, in the longer term future, a BRT line

has been proposed in the Tabata rail corridor and certain efficiencies for BRT would be undeniable. The main deterrent to a dual overbridging function is cost: the flyover is not only longer, but also higher, than other variants: costs are likely to escalate considerably.

- An overbridging of Tazara Intersection proper via a 500 meter flyover. The previous simulation ("flyover case") is based on such a configuration. As noted, considerable benefits already accrue to motorists with this type of flyover.
- An underpass of Tazara Intersection. While certain aesthetic benefits are undeniable (no flyover structure), three factors speak against this approach: very high cost; a likely need for considerable relocation of public utilities; and, a need for mechanical pumping during the rainy season.



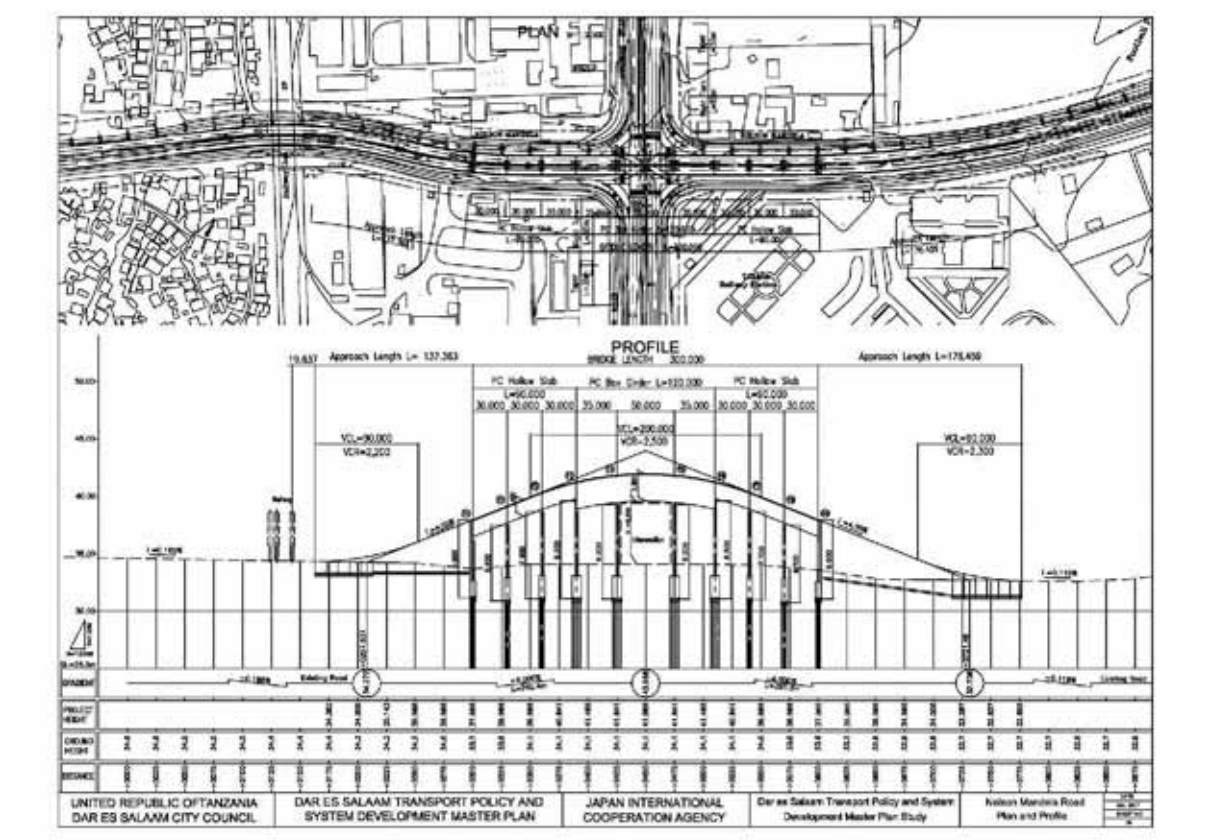
Source: JICA Study Team

Figure 5.3.9 Potential Alternative Configurations Nelson Mandela Road Crossing of Nyerere Road

It is the opinion of the Study Team the most appropriate course of action at this location is construction of an approximately 500 meter flyover bridging Tazara Intersection proper.

A preliminary design has been developed based on a total "nose to nose" length of 540 meters, 250 meter bridge, and approaches of 160 and 130 meters. The total flyover width is estimated at 17 meters, accommodating two 2-lane carriageways, each at seven meters. Slope is calculated at four percent (**Figure 5.3.10**).

Previous discussions with stakeholders confirm the desirability of this solution. Technical liaison is, at time of writing, on-going with a particular view toward determining the type of bridge, which in turn is a direct determinant of cost.



Source: JICA Study Team

Figure 5.3.10 Concept Design: Nelson Mandela Road Flyover at Nyerere Road

5.3.6 The Way Forward

Traffic demand at Tazara Intersection is pronounced already at present, and expected to further escalate in future. Current peak hour sufficiency reviews confirm the intersection is operating at an unacceptable high saturation ratio, one of the worst monitored in the study area. Nelson Mandela Road is being improved over some 16 kilometers, largely within existing alignments, between approximately the seaport and Morogoro Road. The existing multi-lane cross-section will be retained, but considerable enhancements of road surface, drainage and traffic control are foreseen. The project is

being sponsored by the European Commission, with completion expected in approximately two years. Current plans at Tazara Intersection call for implementation of geometric improvements and a high-order signal system. While this will undoubtedly catalyze many improvements to intersection operation, the Study Team is of the opinion that any at-grade solution represents only a near to mid-term benefit, and that growing traffic volumes will likely overwhelm any at-grade betterment in due course.

Previous sections have confirmed the desirability of implementing a Nelson Mandela Road flyover at Nyerere Road. Discussions have been initiated between TANROADS, the European Commission, the Study Team and other stakeholders with a view to potentially integrating this facility with the recently initiated upgrading of Nelson Mandela Road. Technical liaison was made with main foci being

engineering design aspects, and consequent cost implications.

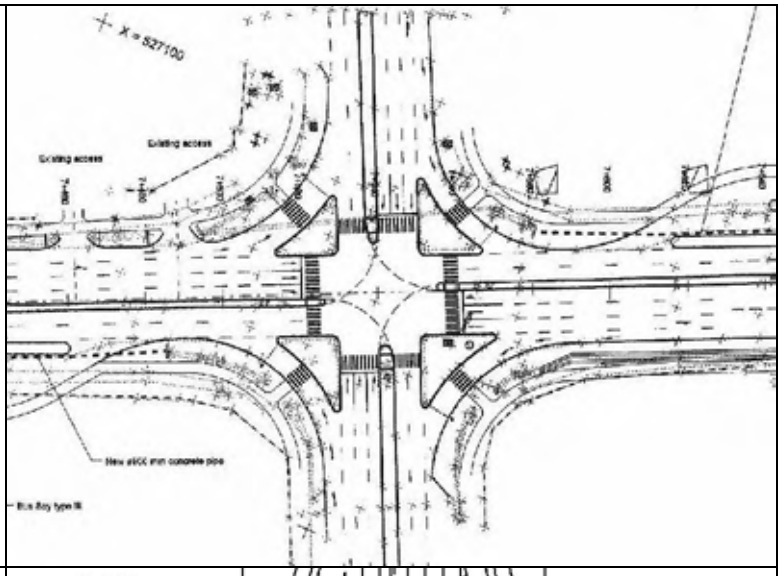
In light of this cooperation and coordination, it is concluded that the flyover solution should proceed. Furthermore, the flyover solution is consistent with the spirit and intent of the at-grade solution, and completely compatible with subsequently needed infrastructure for the Phase 2 BRT Nyerere Road BRT system (**Figure 5.3.11**). Nevertheless, required outlay should be justified via a rigorous economic feasibility review related to operating cost savings, time savings and rates of return on investment.

- **It is therefore suggested that the proposed Tazara Intersection flyover solution be subjected to further pre-feasibility reviews.**

This suggestion was subsequently adopted by the Steering Committee, with the resultant pre-feasibility review detailed in *Volume 3* of this report.

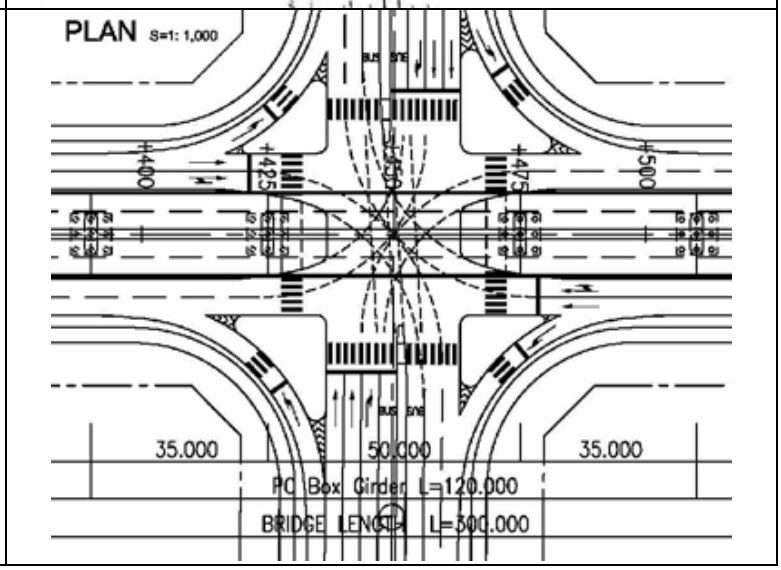
Current at-grade Solution

- Inclusion of service roads for additional capacity and land use access.
- Layout largely follows current geometric conditions.
- Installation of state-of-the-art signal system.
- Enhanced markings, signage, channelization, controls and geometrics.
- All traffic activity at grade.
- Reconstruction needed for implementation of BRT along Nyerere Road.



Potential Flyover Solution

- Compatible with concept embodied in at-grade solution
- North-south traffic along Nelson Mandela Road via flyover. All other traffic activity at grade.
- Enhanced markings, signage, channelization, controls and geometrics.
- Installation of state-of-the-art signal system.
- Optimum positioning of right-turn lanes under flyover to minimize space.
- Compatible with provision of future BRT along Nyerere Rd



Source: JICA Study Team

Figure 5.3.11 Overview of Current At-grade and Flyover Solutions at Tazara Intersection

5.4 Gerezani Area Transport Enhancement Project

The previous intersection review has, in a synoptic sense, identified concerns regarding the evolution of transport systems in the Gerezani area. This subsection addresses this issue in greater detail.

5.4.1 Orientation

The Gerezani area is located approximately south/southwest of the Dar es Salaam CBD. Bandari Intersection (Kilwa Road, Bandari Street) is an identified key intersection (**Figure 5.4.1**).

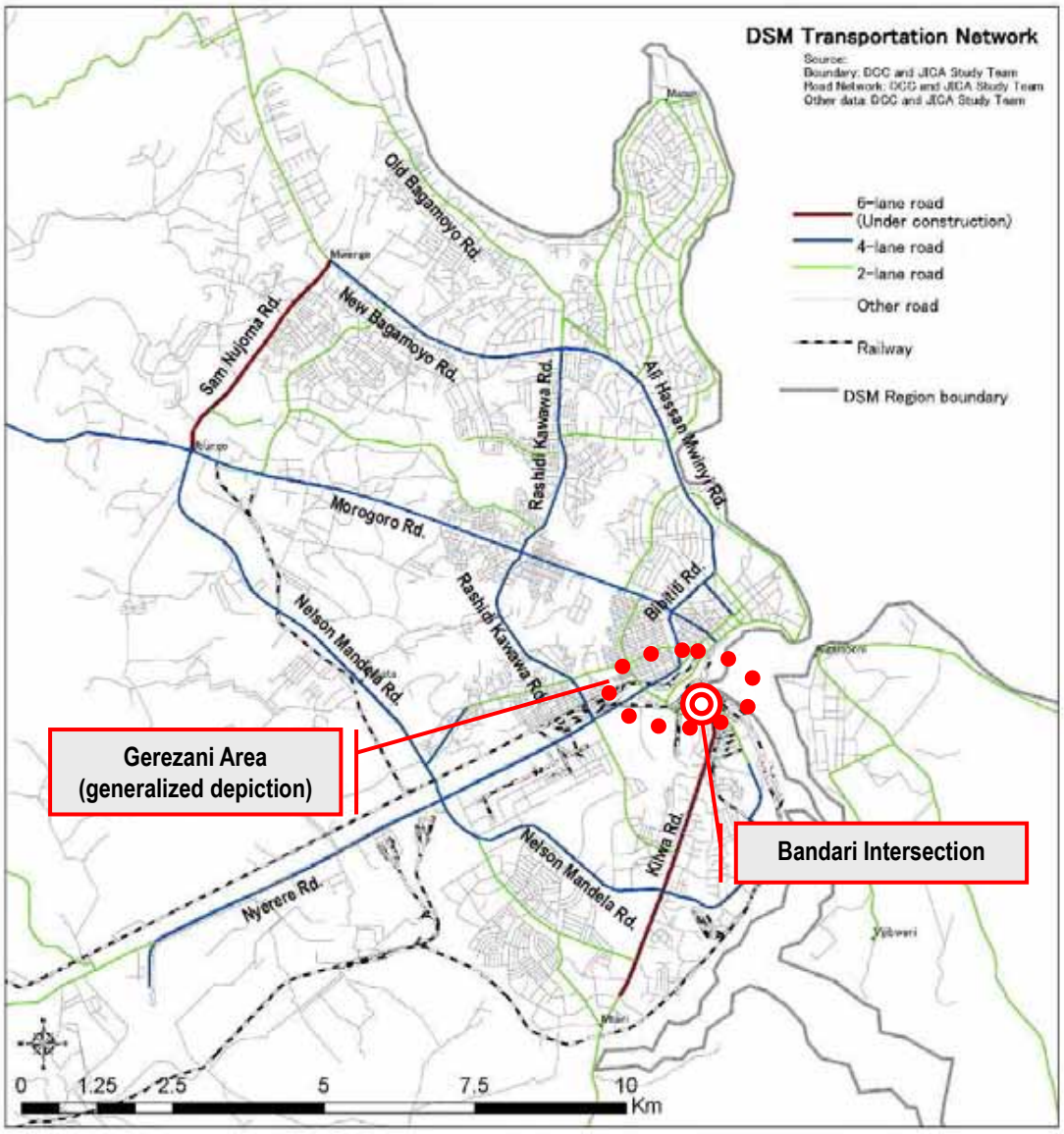


Figure 5.4.1 Locations of Gerezani Area and Bandari Intersection

Kilwa Road is being widened over a distance of approximately 12 kilometers extending south of its northern terminus at Bandari Intersection. The improved cross-section will consist of four mixed traffic lanes (two in each direction), with sufficient median reserve to accommodate a future two-lane BRT busway. The project is sponsored by the Government of Japan and due for completion at the beginning

of 2009. Under the proposed road functional classification scheme (refer Chapter 2, this volume), Kilwa Road will be designated a Type II Primary Arterial with four mixed traffic lanes, two BRT lanes and at-grade pedestrian crossings to the median BRT stations.

No other road improvements are currently programmed in the immediate area. Bandari Road will retain a two lane cross-section. In addition, there are two rail crossings between Kilwa Road and Nyerere Road, one being a bridge (road over rail), the other a disused at-grade crossing. Bandari Road is flanked by various land use developments, and features a right-of-way of 20 meters. Sokoine Drive, also a two-lane road, intersects Bandari Road west of Kilwa Road at the Gerezani Roundabout, from which point it traverses north to the CBD. Sokoine Drive is flanked by intermittent land uses, and has recently been the subject of considerable upgrading of pedestrian walkways and amenities.

The proposed BRT plan (refer beginning Chapter 10 this volume) calls for, in addition to the committed Phase I project, three additional future BRT corridors (Nyerere Road, Tabata rail corridor, Kilwa Road) in the immediate area as well as major central area BRT stations at Kariakoo, Dar es Salaam City Council (DCC) and the Railway Street rail station (**Figure 5.4.2**). The Kilwa Road system is scheduled for BRT Phase 3 implementation during years 2012 and 2013. This assumes construction of the BRT will take 12 months to complete.

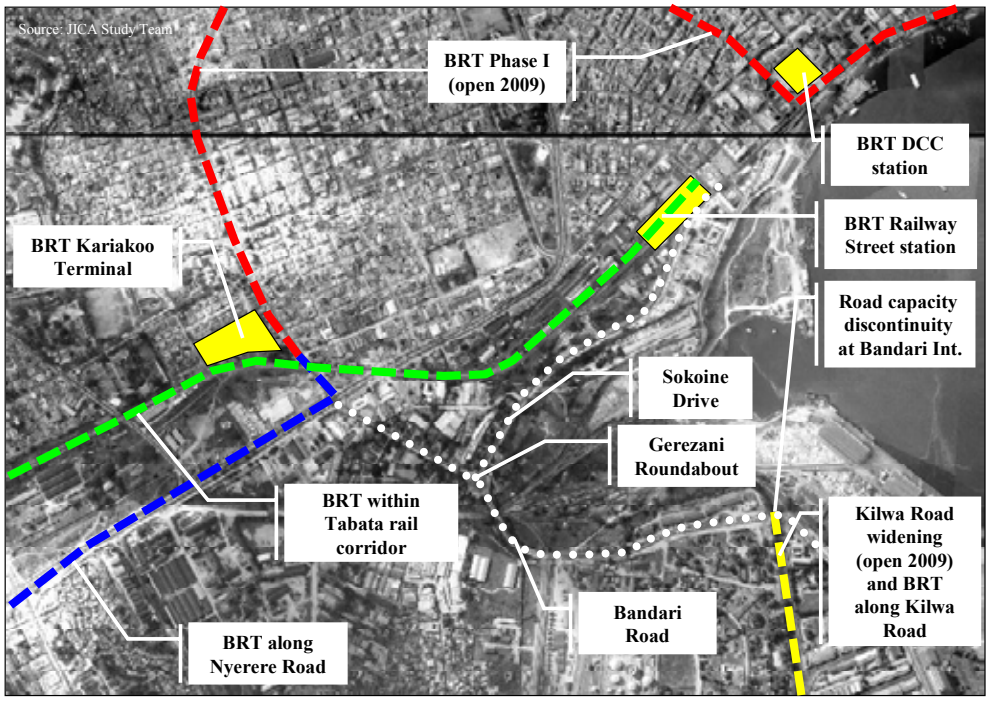


Figure 5.4.2 Major BRT Elements in the Gerezani Catchment

Four core concerns are apparent:

- Bandari Intersection is part of the Kilwa Road widening project. However, current designs call for the termination of the six lane Kilwa Road improvement (four arterial lanes plus two BRT lanes) at the intersection. Bandari Road features a two-lane (one lane per direction)

cross-section; resultant quantum changes in capacity are likely to catalyze considerable congestion at Bandari Intersection.

- The Kilwa Road improvement, as noted previously, terminates abruptly at Bandari Intersection. Road system continuity must be established via linkages either to the west (direction Nyerere Road) and/or the north (direction CBD).
- A need to link the Kilwa Road BRT system with other BRT lines, and/or the major BRT stations at Kariakoo, DCC and Railway Street station.
- Any solution must not funnel additional traffic into the CBD, whose intersections and pedestrian systems are already operating at capacity.

5.4.2 Options for BRT

The resolution of identified concerns involves three intrinsically interlinked considerations:

- The needs of public transport, which at present (Kilwa Road Dala Dala activities) average some 4,500 passengers per morning peak hour. The prioritization of public transport, most specifically BRT, is a stated goal of the Master Plan. BRT solutions must therefore be sensitive to efficiency of operation, passenger convenience and bus operational costs.
- A logical, cohesive and balanced road network whose implementation is technically reasonable and financially affordable. Upgrading of roads must be directly integrated with the provision of BRT busways. The solutions impacting roads will clearly involve Bandari Road and Segoine Drive; however, a further option is to implement new infrastructure which, in a general sense, resembles a northward extension of Kilwa Road, direction CBD, involving a bridging of seaport properties.
- Environmental concerns, most directly the fostering of a more pedestrian-friendly ambience within the CBD. This implies that the provision of roads capable of funneling yet more traffic into the CBD should be avoided in light of already existing road capacity constraints.

Four options relating to the operation of BRT have been identified (**Figure 5.4.3**):

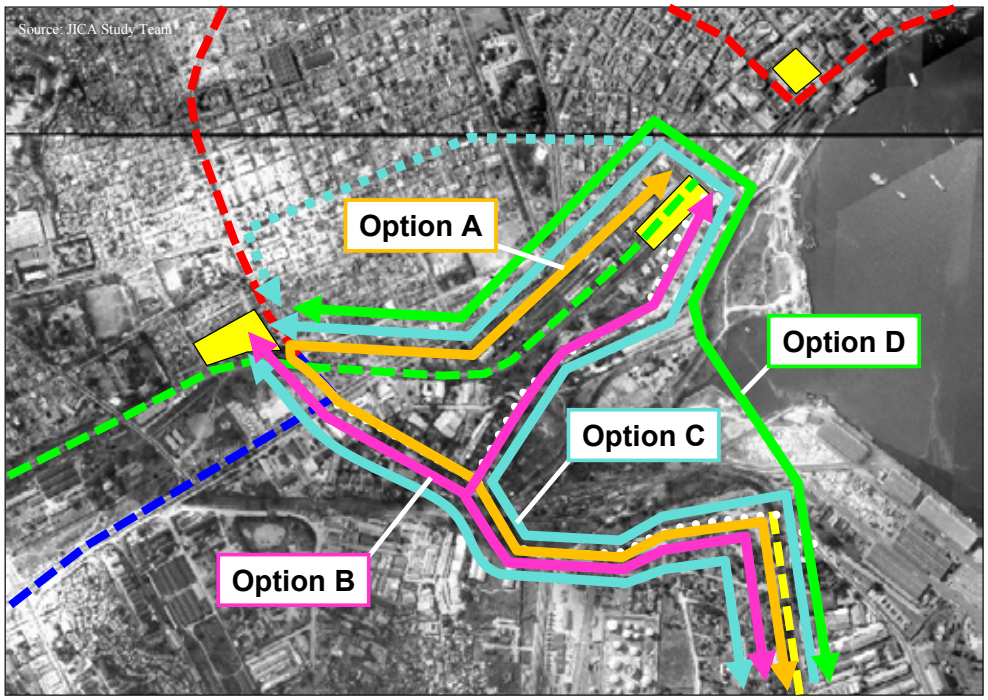


Figure 5.4.3 Alternative BRT Service Options

- Option A is the seemingly logical alternative being to maintain the present Bandari - Gerezani Roads corridor. Widening to manage anticipated volumes of all traffic will be needed. This would be to six lanes, identical to the Kilwa Road upgraded design (four mixed traffic lanes plus median-sited BRT lanes). BRT under Option A operates a two way service to Kariakoo Terminal then joining the Tabata BRT corridor to the Railway Street Station. As the BRT will need to cross Nyerere Road a flyover for the exclusive use of BRT will be required. Option A is also the most circuitous BRT route having to "double back" from Kariakoo Terminal to complete the connection to the CBD.

- Option B is a variation where the BRT operation uses two routes, in essence splitting the Option A service concept. One route would operate two-way between Kilwa Road and Kariakoo Terminal, while the second would access the CBD via a Sokoine Drive routing. Physical construction requirements are a six lane road along the Bandari-Gerezani Roads axis and a BRT-only flyover at Nyerere Road (all being identical to the Option A requirement). However, under Option B, there is an additional need to widen Sokoine Drive to accommodate a BRT busway. Thus, while Option B provides a more direct BRT connection to the CBD, there arises a need for additional road lanes in terms of widening Sokoine Drive. There also exists the underlying issue that the BRT busway along Sokoine Drive parallels (and duplicates) the Tabata rail line alignment. While this, in itself, is not a major problem, it is a duplication vis-à-vis routings contained in other options.

- Option C is a variant of Option B in that the BRT route operating along Sokoine Drive will operate as a one-way route returning via the Tabata corridor BRT busway to Kariakoo

Terminal, then joining the Gerezani-Bandari Roads BRT facility to return to Kilwa Road. Physical construction requirements are the same as Option A, with road-marking work on Sokoine Drive to accommodate a one-way BRT service. This option may be less attractive than Option B as all CBD travel is routed via Kariakoo Terminal, thus increasing travel time for CBD passengers. Changing the route to the opposite direction during some hours (say afternoon peak period) is possible, but can be confusing to passengers and required a high level control system to manage bus operations safely.

- Option D is building an elevated road link across the seaport area for the exclusive use of BRT, with additional lane facilities for pedestrians and non-motorized vehicles. The BRT operation would be direct to the Railway Street station, then joining the Tabata BRT line to Kariakoo Terminal. There would be no BRT operating along Bandari Road and Sokoine Drive. Option D, like Option A, implies longer travel time for Kariakoo Terminal boarders in that the bus will first travel to the CBD.

There is variance in operating costs between options as the route distance under Option A is some one kilometer longer than the other options. The resulting increased operating time will require one additional bus to maintain identical headways. The amortized bus cost, plus additional operating distance, adds some US$300,000 to the annual cost of BRT operation.

Several additional considerations are noted:

- The new road link crossing (bridging) the port area could be expanded to also carry mixed traffic. However, this is rejected out of hand in that the CBD cannot cope with additional traffic, given that at present already CBD intersections are operating at or near capacity. The mixed traffic link is therefore not compatible with the CBD traffic plan (refer Chapter 8, this volume, for additional discussion).
- A BRT-only flyover across Nyerere Road is a vital requirement. Not providing such a facility will be a major constraint to the BRT. The flyover is therefore included in all relevant BRT options.
- The BRT service strategy embodies use of the disused Tabata rail corridor for BRT service. This corridor, which links the CBD with vicinity of Ubungo Intersections, is an important part of the overall service strategy. If BRT is denied in this corridor, than only the previous Option C is seen as being viable using a one-way service concept along Uhuru Road (dashed line in previous graphic).
- Option D, while providing a very direct CBD service, embodies a more circuitous linkage with Kariakoo Terminal. Some BRT enhancements along Nyerere Road east of Msimbazi Street will be needed, but will impact heavily on traffic in this area.
- The use of two separate routes along Kilwa Road for Options B and C has no service disadvantage as it is not difficult for passengers to differentiate between two routes along

Kilwa Road. These can readily be differentiated via different destination boards, or perhaps color schemes. But both options imply an increase in service headways (longer average wait) as only every second bus will travel to any particular destination lying beyond the "route branching point".

5.4.3 Integrating Road and BRT Needs

The formulation of a road enhancement strategy is in fact a fusion of BRT needs (in terms of busway) as well as requirements of mixed traffic (hence road widening) due to increasing demand and/or constraints on capacity. A particular concern from the road perspective is the number of lanes discontinuity at Bandari Intersection following completion of the on-going Kilwa Road improvement project. The various road enhancements are presented in following paragraphs; for ease of discussion, each is identified with a particular BRT option.

- Option A: The core requirement is that Bandari Road will require widening to six lanes (four mixed traffic, two BRT) between Kilwa Road and Kariakoo Terminal, over a total distance of 1.67 kilometers (**Figure 5.4.4**). In addition, a BRT-only flyover across Nyerere Road is needed for this option (as it is for other options). A concept design of the flyover, being in accordance with the 'special roads" categorization of the proposed functional road classification plan, is depicted in **Figure 5.4.5**.

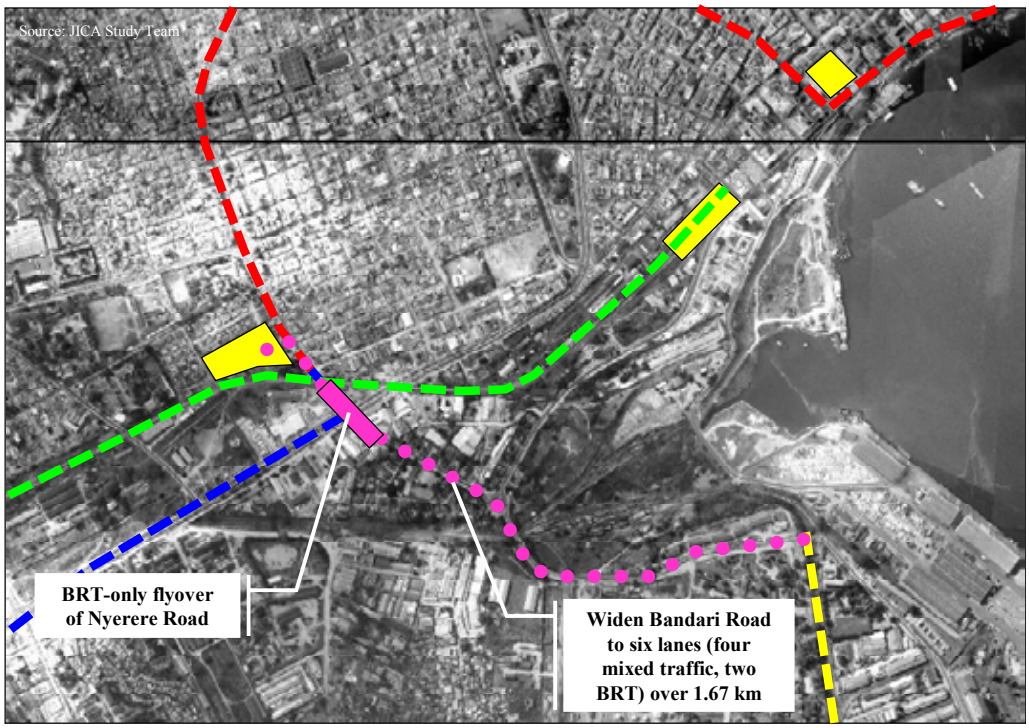
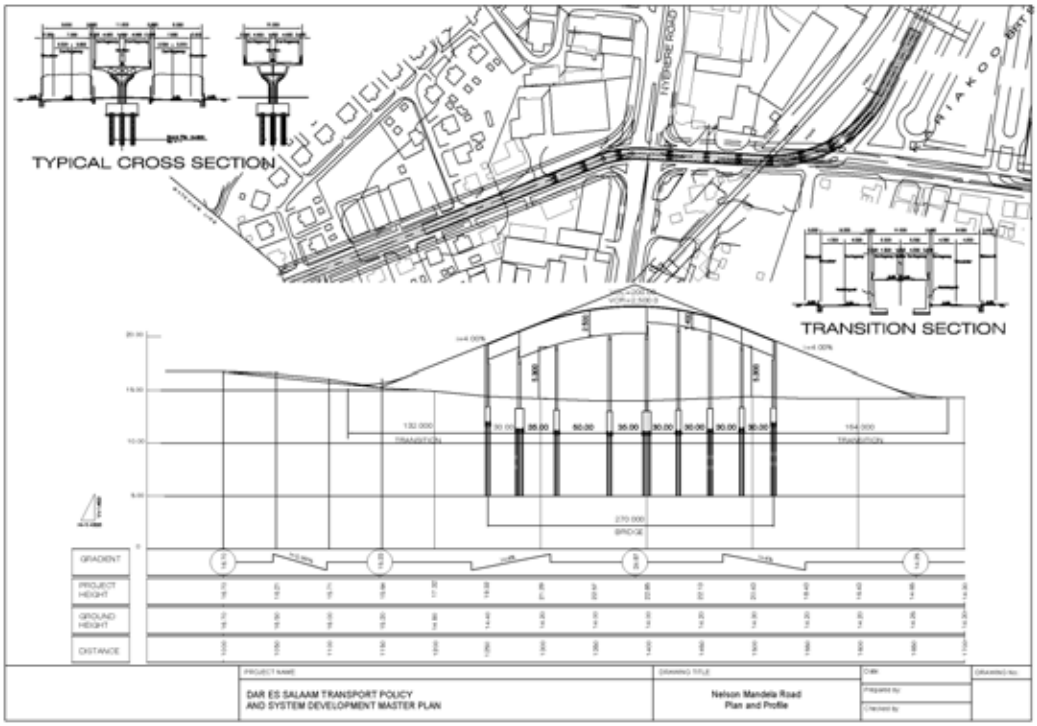


Figure 5.4.4 Road Enhancement Implications: BRT Option A

- Option B: Identical Option A, with the addition of widening needed along Sokoine Drive over a distance of 1.45 kilometers. Widening would be to four lanes, accommodating two mixed

traffic plus two BRT lanes (**Figure 5.4.6**). A concept design of the Sokoine Drive widening is depicted in **Figure 5.4.7**.



Source: JICA Study Team

Figure 5.4.5 Concept Design: BRT-only Flyover at Nyerere Road

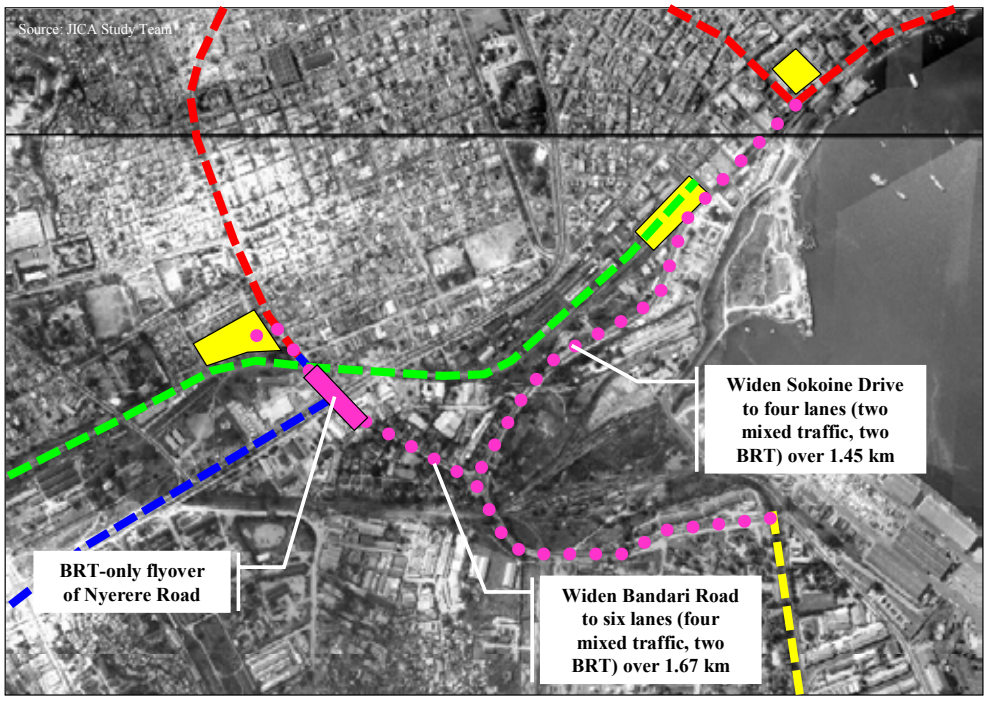


Figure 5.4.6 Road Enhancement Implications: BRT Option B

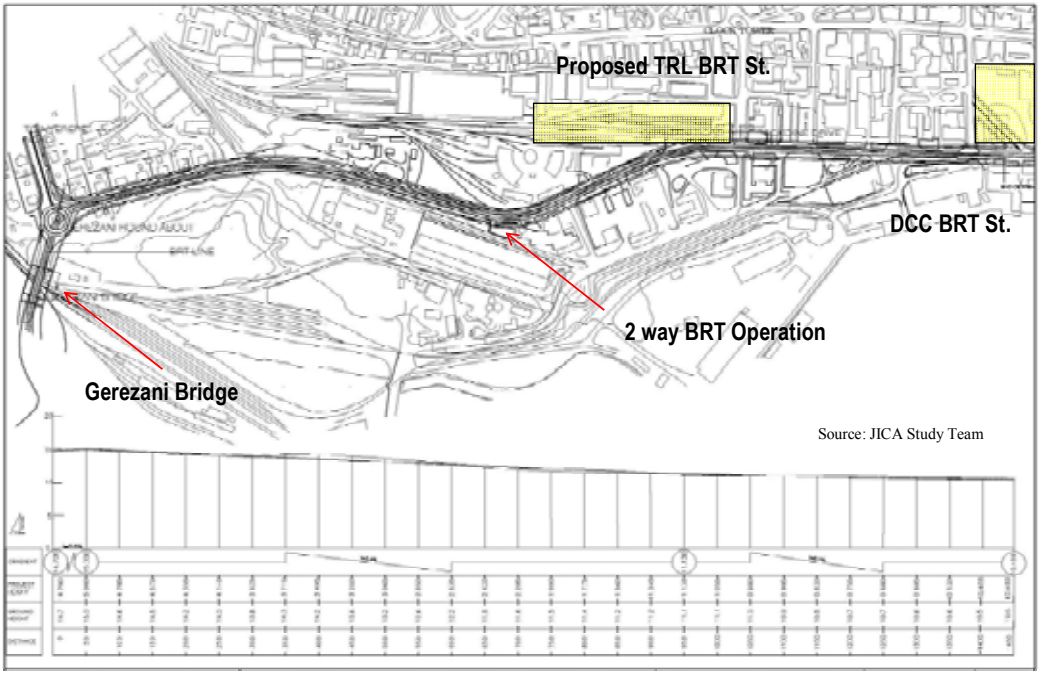


Figure 5.4.7 Concept Design: Sokoine Drive Widening

- Option C: The road implications are identical to those of Option A, with the exception that, due to proposed one-way BRT operation along Sokoine Drive, widening would no longer be needed. Instead, appropriate markings and control, plus possible site-specific BRT priority treatments, would be applied (**Figure 5.4.8**).

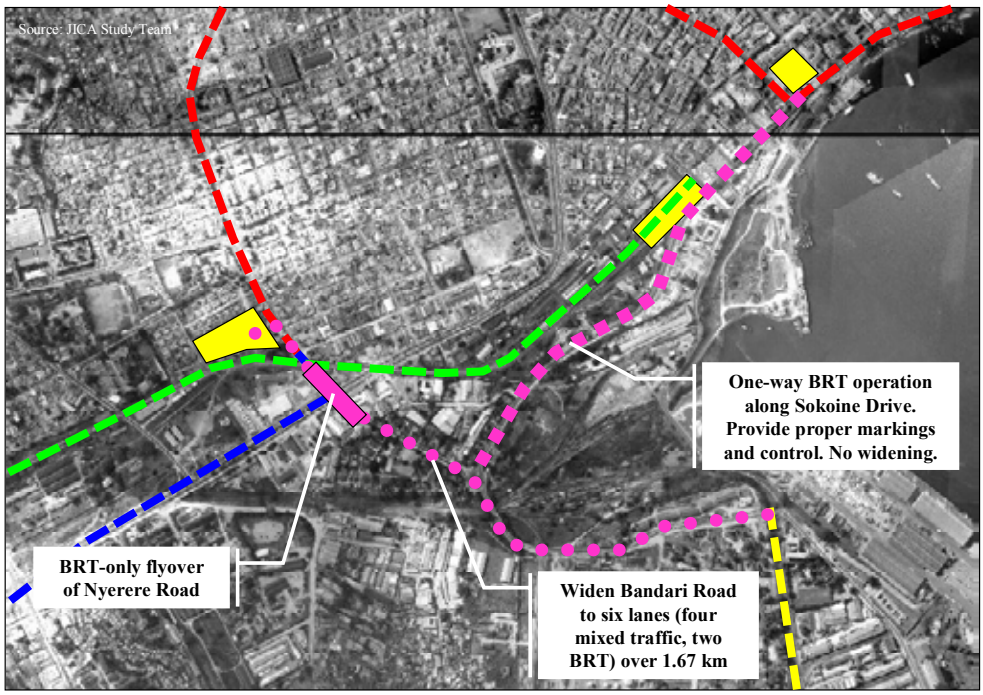


Figure 5.4.8 Road Enhancement Implications: BRT Option C

- Option D: This variant provides a more comprehensive (and capital intensive) approach to problem solving. Bandari Road will require widening, but only to four lanes in that the main focus of the improvement is road capacity uniformity; BRT will not operate along Bandari Road. The BRT-only flyover at Nyerere Road, included in the previous three options, will not be required under Option D. The BRT service will instead continue north from Bandari Intersection, bridging port property via a BRT bridge. This facility would, in addition to BRT, also accommodate pedestrians and non-motorized vehicles. Widening of Sokoine Drive north of the bridge terminus will also be needed to accommodate two BRT lanes (**Figure 5.4.9**).

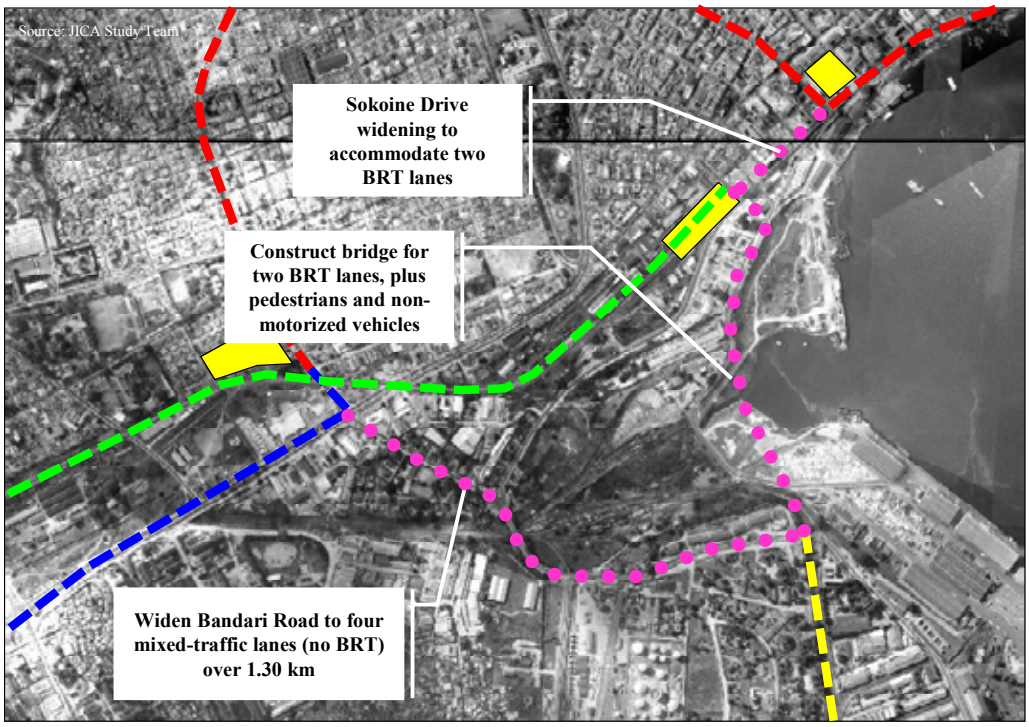


Figure 5.4.9 Road Enhancement Implications: BRT Option D

The conceptual design of Bandari Road widened to four traffic lanes is depicted in **Figure 5.4.10**. Likewise, grades and profiles for the potential facility over-bridging port property is shown in **Figure 5.4.11**.

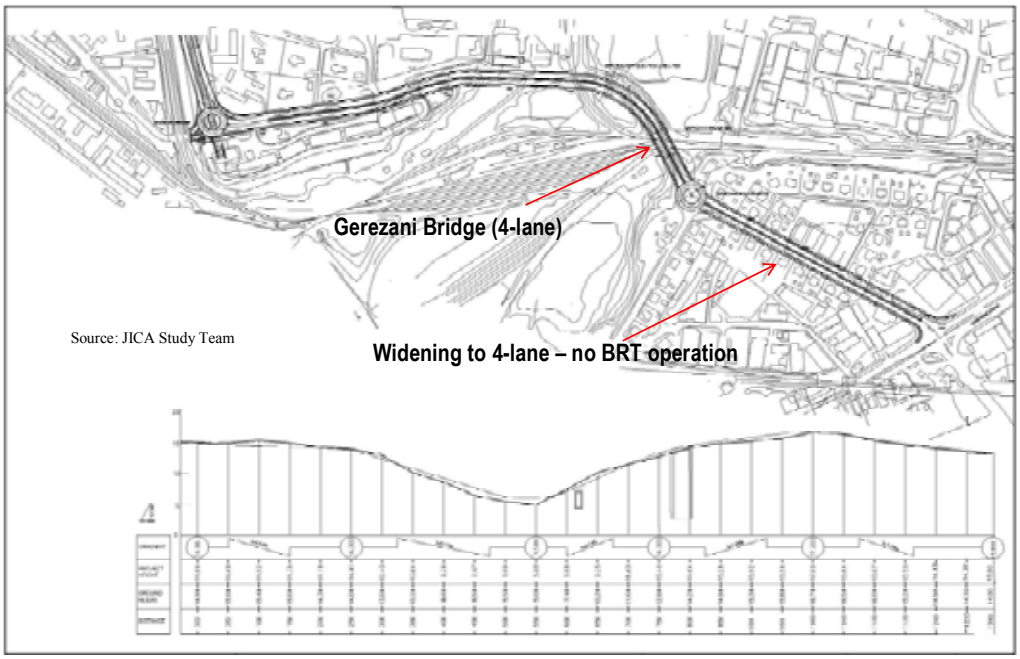


Figure 5.4.10 Concept Design: Bandari Road Widening

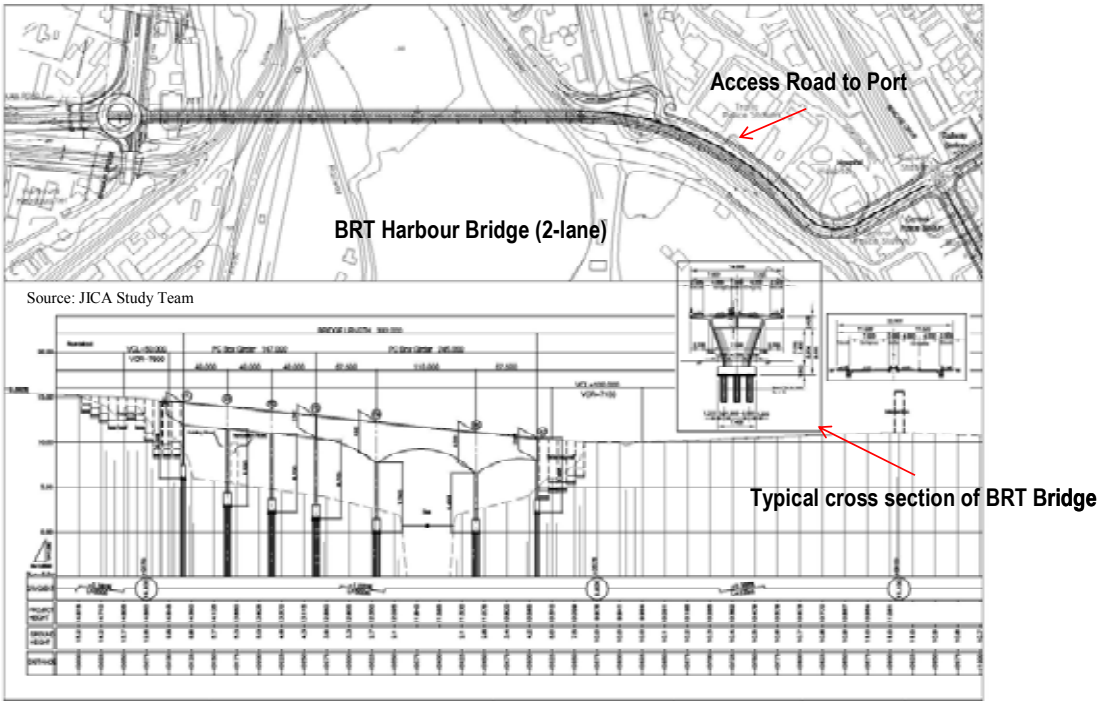


Figure 5.4.11 Concept Design: BRT Port Bridge

5.4.4 The Way Forward

Previous sections have identified several options for BRT and road improvements within the Gerezani area. These are formulated with a view to mitigating perceived shortfalls in BRT service, mainly between the Kilwa Road corridor and CBD/Kariakoo Terminal, as well as capacity discontinuities in

the road network, whose focus is Bandari Intersection under a post-improvement (Kilwa Road) condition.

- Four BRT service scenarios are presented, each of which carry implications in terms of infrastructure provision, service structure and service philosophy (**Table 5.4.1**).

Table 5.4.1 Summary of BRT Service Options

Option	Routing Concept	Operational Description	Nyerere Road Intersection Treatment	Bandari Road Impact	Sokoine Drive Impact	Conformity to CBD Traffic Plan	Directness of Service	Avoids BRT Duplication
A		Bandari Road to Kariakoo Terminal, then onwards to CBD	Flyover	Widen to six lanes	None	Yes	CBD – Low Kariakoo - High	Yes
B		Bandari Road to Kariakoo Terminal; Sokoine Drive (two-way) to CBD	Flyover	Widen to six lanes	Widen to four lanes	Yes	CBD – Medium Kariakoo - High	No
C		Bandari Road to Kariakoo Terminal; Sokoine Drive (one-way) to CBD then Kariakoo Terminal	Flyover	Widen to six lanes	None other than markings and control	Yes	CBD – Medium Kariakoo - High	No
D		Port Bridge to CBD, then onwards to Kariakoo Terminal	None	Widen to four lanes (no BRT impact)	Widening at northern bridge terminus	Yes	CBD - High Kariakoo - Medium	Yes

Source: JICA Study Team

- The integration of BRT and road improvement needs implies that various forms of upgrading could be applied, whether for existing facilities or in the form of new infrastructure. Each of these opportunities carries financial implications (**Table 5.4.2**).

It is tempting to surmise that, for example, Option A is a preferred strategy given that reasonable BRT service is provided, and infrastructure cost is least vis-à-vis other promulgated options. However, the underlying rationales run deeper, implying various layers of economic feasibility related to operating cost savings, time savings and rates of return on investment. There are also issues regarding right-of-way requirements: for example, it is anticipated that, in all options except Option D, right of way acquisition for widening is necessary.

- **It is therefore suggested that the identified Gerezani area transport enhancement options be subjected to further pre-feasibility review.**

This suggestion was subsequently adopted by the Steering Committee, with the resultant pre-feasibility review, and ultimate decision as to the preferred option, detailed in *Volume 2* of this report.

Table 5.4.2 Summary of Road Improvement Implications

BRT Operation Options	Road Length to be improved	Typical Cross Section	Major Required Structure			Preliminary Cost Estimate (Tanzanian Shillings)	Construction period (years)
			Flyover	Bridge	Box Culvert		
A	Bandari/Gerezani:1300m + 370 m to Kariako BRT terminal	Total width: 34m six-lane road (9m median for BRT 2-way operation, 2 carriage way @ 9.5m, side walk @3m)	Bridge: PC hollow girder 260m length, 265m transition, 11m width for BRT exclusive line, eight spans	35m length, 34m width of T type PC Girder, single span, pile foundation	3.5m*5.0m, 52m single shell	20.9 billion	2.0
B	Bandari/Gerezani:1300m + 370 m to Kariako BRT terminal + Sokoine 1,450m	Bandari/Gerezani Roadsas as per Option A; Sokoine Drive one carriage way @ four lanes (BRT plus mixed traffic lanes)	Same as Option A			26.6 billion	2.5
C	Largely identical to Option A; modest additional costs to be expected for marking and controls along Sokoine Drive.						
D	Bandari/Gerezani:1300m + 370 m to Kariako BRT terminal + BRT Bridge	Bandari/Gerezani Roads: 27m four-lane road (2m median, two carriageways @ 9.5m, footpaths @ 3m Bridge width : 9m for two BRT lanes; 2.5m for pedestrian and NMV walkway	PC hollow girder 260m length, 265m transition, 11m width for BRT exclusive line, 8 Spans		3.5m*5.0m, 41m single shell	33.1 billion	3.0

5.5 Conclusions and Recommendations

Previous sections in this chapter have reviewed various key intersections or impact areas. Conclusions and recommendations arising from those reviews are summarized below.

5.5.1 Priority Intersections

The review of Dar es Salaam priority intersections, as documented in subsection 5.1, is inclusive of a variety of considerations and leads to a series of conclusions. These are:

- The highest priority locations in terms of needed action include Ubungo Intersection, Tazara Intersection and Bandari Intersection (involving several possible solutions in the surrounding Gerezani area) (**Figure 5.5.1**).

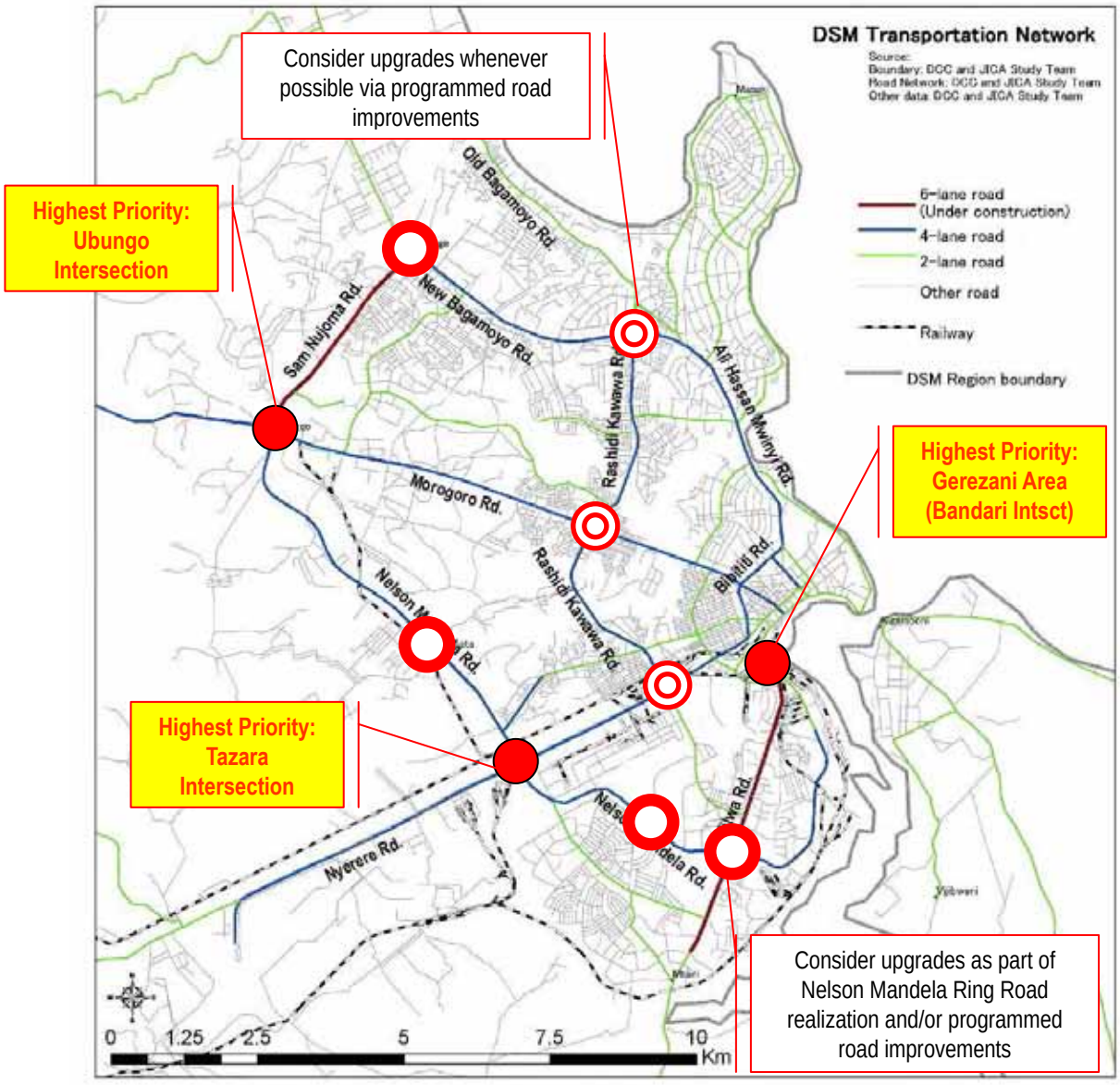


Figure 5.5.1 Priority Arterial Intersections Targeted for Upgrading

- Reinforcement of the Nelson Mandela Road beltway is seen as a highly desirably strategy. As also reviewed as part of the longer-term road network, the belt represents an important circumferential route for heavy commercial vehicles and other users alike. If adopted solutions at the Ubungo and Tazara Intersections follow the Study Team recommendation of flyovers, then grade separation should be in direction of the belt. It is anticipated that the Mwenge Intersection (Sam Nujomo and Bagomoyo Roads) will offer next, after priority sites, opportunity for flyover implementation as part of the programmed New Bagomoyo Road widening.
- Morocco and Magomeni Intersections could well be optimized as part of programmed improvements. Chang Ombe Intersection, in turn, could be upgraded in line with BRT realization, although it is desirable to concurrently expand the Chang Ombe profile.

- The Selanda Bridge area has clearly emerged as a congested area. While intersections flank the bridge, it is unlikely that intersection-specific solutions will rectify this situation. Instead, more rigorous approaches are needed as pursued within the framework of the longer-term Master Plan solutions. Further solutions relate to the CBD Traffic Plan, presented in Chapter 8 of this volume.

5.5.2 Ubungo Intersection

The main conclusions of the subsection 5.2 review of Ubungo Intersection (Nelson Mandela, Sam Nujomo and Morogoro Roads) are, in summary:

- The Study Team is fully supportive of the BRT concept, and is in full agreement with the implementation of this exciting mode in Dar es Salaam. The BRT concept has been fully integrated within the framework of the *Master Plan* and is seen as a cornerstone in the provision of enhanced urban mobility. While the current proposal for the BRT Phase I system is the result of considerable and thorough professional investigations, the proposed concept contains a BRT-centric approach and, in the opinion of the Study Team, broader perspectives are needed to ensure that other modes of traffic (to include other buses, heavy commercial vehicles – in particular articulated long-distance trucks - and cars) are not overly and unnecessarily penalized by the introduction of BRT.
- The BRT Phase I design, as currently proposed, causes unwanted delay and operational difficulties at Ubungo Intersection, largely due to U-turn facilities proposed north and south of Morogoro Road. It is, in the opinion of the Study Team, highly desirable to raise these issues prior to begin of Phase I construction.
- The Study Team is fully aware of the need for a quick resolution of the identified concerns as the Phase I system is rapidly moving towards implementation. Yet, concurrently, alternative solutions require more detailed review to ensure that physical and operational criteria are fully met to the satisfaction of the Government of Tanzania and the World Bank. In the opinion of the Study Team, this is possible with a concerted "fast track" approach to problem solving.
- The solution can follow two generic paths. Firstly, if only the needs of BRT are considered, to the exclusion of other modes in the mixed traffic stream, than the current BRT Phase I concept fulfills these expectations and no concept adjustments are needed. However, if the broader needs of all intersection users are considered, there indeed exists a need to "fix the intersection".
- An optimization of Ubungo Intersection from the existing Phase I concept is possible considering current levels of demand. Proposed adjustments include the adoption of four-phase signalization, inclusion of right-turns at the intersection proper (hence no U-turn facilities as currently proposed by the BRT Phase I concept), the reduction of Dala Dala activity per a post-BRT scenario, and the relocation of the Ubungo Dala Dala terminal access point (both as proposed by the BRT Phase I concept).

- Implementation of this change will entail modification of the BRT Phase I concept. However, adjustments to the Phase I-proposed layout, in particular removal of the proposed U-turn facilities and the retention of right-turn lanes, are not seen as being technically difficult (assuming physical conditions so permit) nor excessively time consuming. However, several foreign sponsoring entities, in addition to the Government of Tanzania, are stakeholders in intersection improvements; thus immediate coordination (and cooperation) is essential.
- The indicated modification is likely, in the short to medium term future, to cater for anticipated intersection demand. However, in the longer term, increasing traffic may overwhelm this at-grade solution. More robust cures will be needed to "fix the intersection". The current investigations suggest that construction of a mixed traffic flyover, using to split (portal) design to account for future BRT lanes along Sam Nujomo Road, is likely to offer most benefit in terms of intersection (and indeed corridor) traffic operations. It is suggested that the flyover be constructed along the Nelson Mandela-Sam Nujoma Roads axis, thus reinforcing the "inner ring road" concept whose realization will preempt "congestion transfer" to downstream junctions.
- The potential construction of a future flyover carries two important implications: (a) to ensure that the final Phase I layout (at-grade solution) is, as practical and possible, compatible with future intersection configurations to prevent duplication of effort and wasted use of scarce financial resources; and, (b) timely agreement among stakeholders regarding intersection improvement implementation strategies.

A further issue exists and should be pointed out at this opportune moment.

The Phase I BRT system (Morogoro Road corridor) features two mixed traffic lanes per direction plus the BRT busway. BRT stations are to be provided every 500-700 meters. Station design requires that passengers entering to, and departing from, the median-sited stations must cross Morogoro Road at-grade. Each station will have two walkways in each lateral direction, protected by a "speed bump" design (each walkway will be raised between five and 10 centimeters above street level). This will considerably depress vehicular capacity since, in addition to intersections, there will be at least two "speed bump pedestrian crossings" every 500-700 meters in each direction of travel. This design is also very problematic for heavy commercial vehicles, which currently are numerous on Morogoro Road west of Nelson Mandela Road (the dominant cargo corridor linking upcountry and seaport lies along the Morogoro Road – Nelson Mandela Road axis).

There is considerable concern within the Study Team regarding the safety of pedestrians and BRT users at BRT stations sited within Morogoro Road west of Nelson Mandela Road.

- In the interests of pedestrian safety, as well as enhanced road operations for all members of the traffic stream, the BRT Phase I Morogoro Road stations west of Nelson Mandela Road should be equipped with elevated pedestrian walkways instead of at-grade road crossings.

5.5.3 Tazara Intersection

Traffic demand at Tazara Intersection, as noted in subsection 5.3, is pronounced already at present, and expected to further escalate in future. Current peak hour sufficiency reviews confirm the intersection is operating at an unacceptable high saturation ratio, one of the worst monitored in the study area.

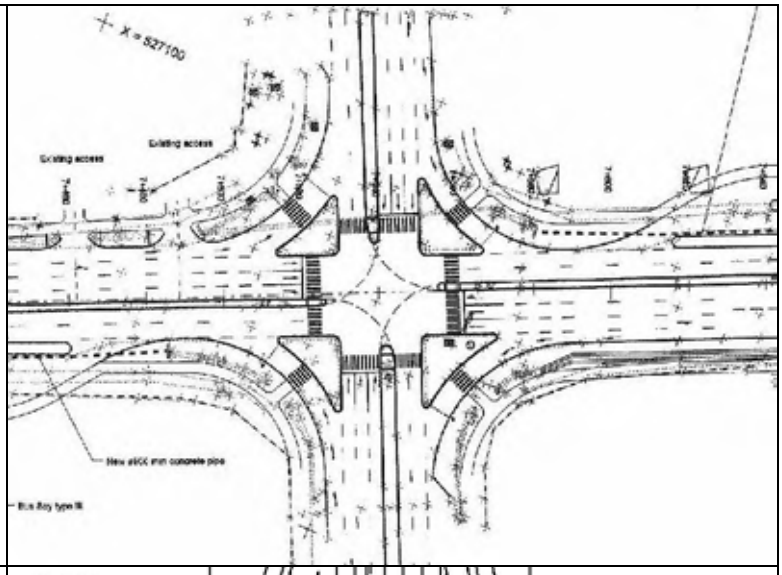
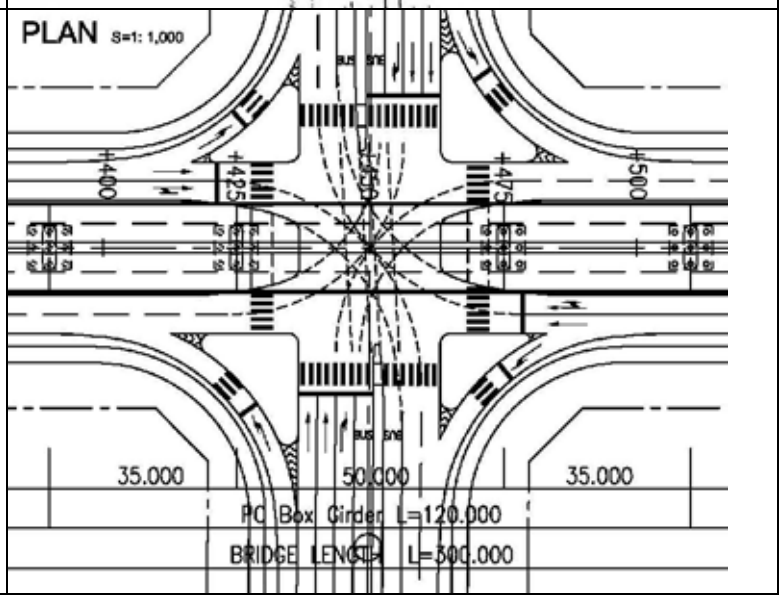
Nelson Mandela Road is being improved over some 16 kilometers, largely within existing alignments, between approximately the seaport and Morogoro Road. The existing multi-lane cross-section will be retained, but considerable enhancements of road surface, drainage and traffic control are foreseen. The project is being sponsored by the European Commission, with completion expected in approximately two years. Current plans at Tazara Intersection call for implementation of geometric improvements and a high-order signal system. While this will undoubtedly catalyze many improvements for intersection operation, the Study Team is of the opinion any at-grade solution at this location represents only a near to mid-term benefit, and that growing traffic volumes will likely overwhelm any at-grade betterment in due course.

Previous sections have confirmed the desirability of implementing a Nelson Mandela Road flyover at Nyerere Road. Discussions have been initiated between TANROADS, the European Commission, the Study Team and other stakeholders with a view to potentially integrating this facility with the recently initiated upgrading of Nelson Mandela Road. Technical liaison is continuing at time of writing with main foci being engineering design aspects, and consequent cost implications.

In light of this cooperation and coordination, it is tempting to conclude that the flyover solution should proceed. Furthermore, the flyover solution is consistent with the spirit and intent of the at-grade solution, and completely compatible with subsequently needed infrastructure for the Phase 2 BRT Nyerere Road BRT system (**Figure 5.3.10**). Nevertheless, required outlay should be justified via a rigorous economic feasibility review related to operating cost savings, time savings and rates of return on investment.

- **It is therefore suggested that the proposed Tazara Intersection flyover solution be subjected to further pre-feasibility reviews.**

This suggestion was subsequently adopted by the Steering Committee, with the resultant pre-feasibility review detailed in *Volume 3* of this report.

Current at-grade Solution • Inclusion of service roads for additional capacity and land use access. • Layout largely follows current geometric conditions. • Installation of state-of-the-art signal system. • Enhanced markings, signage, channelization, controls and geometrics. • All traffic activity at grade. • Reconstruction needed for implementation of future BRT along Nyerere Road.	
Potential Flyover Solution • Compatible with concept embodied in at-grade solution • North-south traffic along Nelson Mandela Road via flyover. All other traffic activity at grade. • Enhanced markings, signage, channelization, controls and geometrics. • Installation of state-of-the-art signal system. • Optimum positioning of right-turn lanes under flyover to minimize space. • Compatible with provision of future BRT along Nyerere Rd	

Source: JICA Study Team

Figure 5.5.2 Overview of Current At-grade and Flyover Solutions at Tazara Intersection

5.5.4 Gerezani Area Transport Enhancement Project

Kilwa Road is, as noted in subsection 5.4, being widened over a distance of approximately 12 kilometers extending south of its northern terminus at Bandari Intersection. The improved cross-section will consist of four mixed traffic lanes (two in each direction), with sufficient median reserve to accommodate a future two-lane BRT busway. The project is sponsored by the Government of Japan and due for completion at the beginning of 2009. The proposed Master Plan BRT plan calls for, in addition to the committed Phase I project, three additional future BRT corridors (Nyerere Road, Tabata rail corridor, Kilwa Road) in the immediate area as well as major central area BRT stations at Kariakoo, Dar es Salaam City Council (DCC) and the Railway Street rail station (**Figure 5.5.3**).

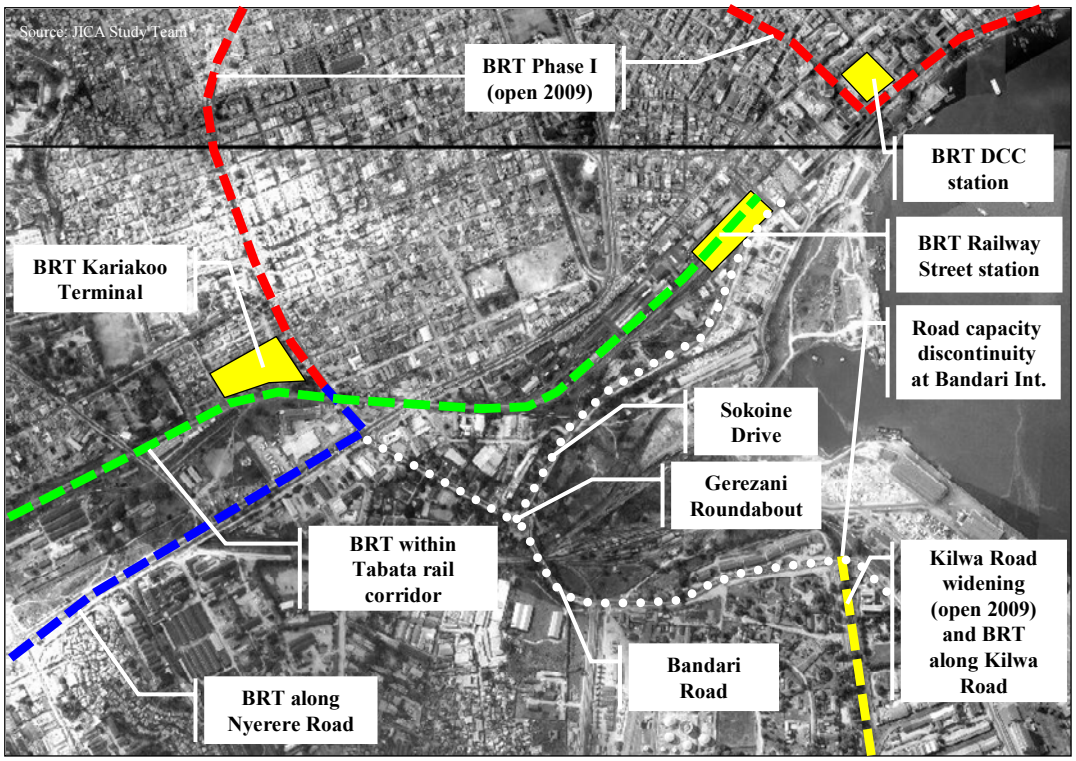


Figure 5.5.3 Major BRT Elements in the Gerezani Catchment

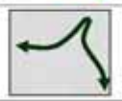
Four core concerns are apparent:

- Bandari Intersection is part of the Kilwa Road widening project. However, current designs call for the termination of the six lane Kilwa Road improvement (four arterial lanes plus two BRT lanes) at the intersection. Bandari Road features a two-lane (one lane per direction) cross-section; resultant quantum changes in capacity are likely to catalyze considerable congestion at Bandari Intersection.
- The Kilwa Road improvement, as noted previously, terminates abruptly at Bandari Intersection. Road system continuity must be established via linkages either to the west (direction Nyerere Road) and/or the north (direction CBD).
- A need to link the Kilwa Road BRT system with other BRT lines, and/or the major BRT stations at Kariakoo, DCC and Railway Street station.
- Any solution must not funnel additional traffic into the CBD, whose intersections and pedestrian systems are already operating at capacity.

Reviews have identified several options for BRT and road improvements within the Gerezani area. These are formulated with a view to mitigating perceived shortfalls in BRT service, mainly between the Kilwa Road corridor and CBD/Kariakoo Terminal, as well as capacity discontinuities in the road network, whose focus is Bandari Intersection under a post-improvement (Kilwa Road) condition.

- Four BRT service scenarios are presented, each of which carry implications in terms of infrastructure provision, service structure and service philosophy (**Table 5.5.1**).

Table 5.5.1 Summary of BRT Service Options

Option	Routing Concept	Operational Description	Nyerere Road Intersection Treatment	Bandari Road Impact	Sokoine Drive Impact	Conformity to CBD Traffic Plan	Directness of Service	Avoids BRT Duplication
A		Bandari Road to Kariakoo Terminal, then onwards to CBD	Flyover	Widen to six lanes	None	Yes	CBD – Low Kariakoo - High	Yes
B		Bandari Road to Kariakoo Terminal; Sokoine Drive (two-way) to CBD	Flyover	Widen to six lanes	Widen to four lanes	Yes	CBD – Medium Kariakoo - High	No
C		Bandari Road to Kariakoo Terminal; Sokoine Drive (one-way) to CBD then Kariakoo Terminal	Flyover	Widen to six lanes	None other than markings and control	Yes	CBD – Medium Kariakoo - High	No
D		Port Bridge to CBD, then onwards to Kariakoo Terminal	None	Widen to four lanes (no BRT impact)	Widening at northern bridge terminus	Yes	CBD - High Kariakoo - Medium	Yes

Source: JICA Study Team

- The integration of BRT and road improvement needs implies that various forms of upgrading could be applied, whether for existing facilities or in the form of new infrastructure. Each of these opportunities carries financial implications (**Table 5.5.2**).

It is tempting to surmise that, for example, Option A is a preferred strategy given that reasonable BRT service is provided, and infrastructure cost is least vis-à-vis other promulgated options. However, the underlying rationales run deeper, implying various layers of economic feasibility related to operating cost savings, time savings and rates of return on investment. There are also issues regarding right-of-way requirements: for example, it is anticipated that, in all options except Option D, right of way acquisition for widening is necessary.

- **It is therefore suggested that the four identified Gerezani area transport enhancement options be subjected to further pre-feasibility review.**

This suggestion was subsequently adopted by the Steering Committee, with the resultant pre-feasibility review, and ultimate decision as to the preferred option, detailed in *Volume 2* of this report.

Table 5.5.2 Summary of Road Improvement Implications

BRT Operation Options	Associated Construction Alternatives	Road Length to be improved	Typical Cross Section	Major Required Structure			Preliminary Cost Estimate (without relocation ,engineering cost and contengency)	Construction period
				Flyover	Bridge	Box Culvert		
A	ALT 1	Bandari/Gerezani:1300m (up to the BRT terminal :1,670m in total)	Total width: 34m 6-lane road (9m median for BRT 2-way operation, 2 carriage way @9.5m, side walk @3m)	Bridge: PC box girder 270m length, 296m transition, 11m width for BRT exclusive line, 8 Spans	35m length, 34m width of T type PC Girder, single span, pile foundation	3.5m*5.0m, 52m single sell	21.6 billion	2 years
B	ALT 2	Bandari/Gerezani:1300m (up to the BRT terminal :1,670m in total) + Sokoine 1,450m	Total width: 34m 6-lane road (9m median for BRTlines, 2 carriage way @9.5m, side walk @3m) ; Sokoine 1carriage way @6m	Same as above			26.6 billion	2.5 years
C	ALT 1	Same as ALT 1, but road operation is different. No BRT on TRL can be considered.						
D	ALT 3	Bandari/Gerezani:1300m (up to the BRT terminal :1,670m in total) + BRT Bridge	Bridge width : 9m for 2-lane BRTand NMV and pedestrian walkway @2.5m, Road: 27m 4-lane road (2m median, 2 carriage way @9.5m, side walk @3m)	(Port crossing Bridge) PC hollow girder 260m length, 265m transition, 11m width for BRT exclusive line, 8 Spans		3.5m*5.0m, 41m single sell	33.1 billion	3.0 years