



The Project for Urban Mobility Improvement in Kigali



The 6th Working Group 2 (1. Evaluation of Intersections and Prioritization of Improvement Projects)
22nd February 2023

JET Member

Traffic Flow Management

1. Mr. NISHINO: Traffic Flow Management/Traffic Control (1)

Traffic Management System

2. Mr. OKUDA: Smart Traffic/ICT

3. Mr. NODA: Traffic Flow Management/Traffic Control (2)

4. Mr. OTSUKA: System Design/Communication

Intersection Improvement

5. Mr. IWAMOTO: Road Planning & Design (1)

6. Mr. SUGANUMA: Road Planning & Design (2)

7. Mr. SHINYA: Road Planning & Design (3)



AGENDA

Session 1: Working Group

9:00-10:00	1h	Evaluation of Intersections and Prioritization of Improvement Projects
10:00-11:00	1h	Basic Design of Intersections (Civil Works)
11:00-12:00	1h	Basic Design of Intersections (Signal System)

12:00-13:00

Lunch Break

Session 2: Lectures

13:00-14:00	1h	Lecture 1: Roundabout Planning
14:00-15:30	1.5h	Lecture 2: Case Study of Intersection Improvement (DBL Route)
15:30-16:00	0.5h	Lecture 3: Signal Phase Planning

Session 1: Working Group

1. Objective of Intersection Design

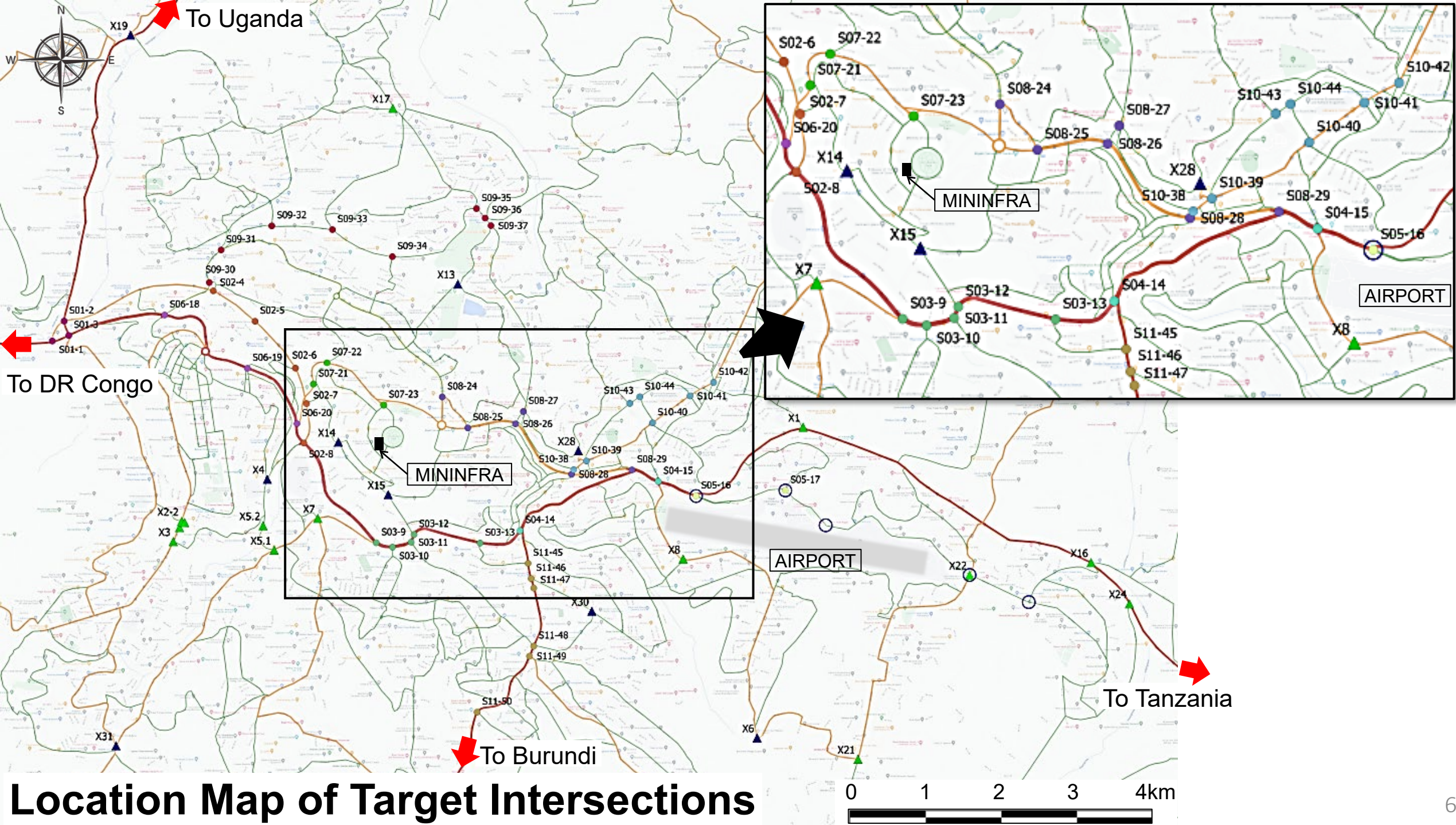
To prepare improvement design of intersections as part of the priority components of the Urban Mobility Improvement Project in Kigali (UMIK), which will result in the Action Plan of the Project.

2. Target Intersections

Original target: 50 Intersections

Additional target: 24 Intersections

Note: These numbers are subject to change depending on the actual situation of the site and/or results of traffic analysis.



3. *Evaluation of Intersections*

Evaluate intersections to prioritize investments.

Evaluation Items

Category	Evaluation Item
Emergency:	✓ Volume to Capacity Ratio (VCR) in Current Situation
Effectiveness:	✓ Traffic Volume of Intersection
Others:	✓ Volume of NMT ✓ Necessity of Coordinated Signal Control (at Adjacent Intersections) ✓ Necessity of Bus Priority (on DBL Pilot Route)

Evaluation of Intersections and Prioritization of Improvement Projects

✓ Volume to Capacity Ratio (VCR) in Current Situation

(1) Signalized Intersection (Case: S07-23, 2025, Worst VCR=2.09)

Approach		1	2			3			4		
Lane		RT·TH·LT	RT·TH	TH	LT	RT Free	TH	LT	RT Free	TH	LT
No. of Lanes		1	1	1	1	2	1	1	1	1	1
Base Saturation Flow S0 (pcu/hr/lane)		2,000	2,000	2,000	1,800	1,800	2,000	1,800	1,800	2,000	1,800
Lane width adjustment factor, fw		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Lane Width (m)		(3.50)	(3.50)	(3.50)	(3.50)	(3.50)	(3.50)	(3.50)	(3.50)	(3.50)	(3.50)
Vertical grade adjustment factor, fg		1.000	0.950	0.950	0.950	0.950	0.950	0.950	1.000	1.000	1.000
Vertical Grade (%)		(-1.00)	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(2.00)	(-1.00)	(-1.00)	(-1.00)
Heavy vehicle adjustment factor, fHV		1.000	1.000	1.000	0.999	0.996	1.000	1.000	1.000	1.000	1.000
Heavy Vehicle Rate (%)		(0.00)	(0.00)	(0.00)	(0.12)	(0.51)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Right-turn adjustment factor, fRT		0.992	0.826								
Percentage of RT (%)		(3.7)	(91.5)								
Possibility of RT Passage FR		0.850	0.850								
Effective Green Time (s)		16	16								
Pedestrian Green Time (s)		11	11								
Left-turn adjustment facotr, fLT		-9.999									
Percentage of LT (%)		(16.6)									
Possibility of LT Passage FL		0.574									
Effective Green Time (s)		16									
Cycle Time (s)		90									
Saturation Flow S (pcu/hr)		*9,999	1,569	1,900	1,708	*3,406	1,900	1,710	*1,800	2,000	1,800
Traffic Volume q		403	142	1,699	1,811	539	145	403	124	2	
		15+321+67	(65+77)								
Flow Ratio		-	0.041	0.886	-	0.284	0.070	-	0.062	0.000	λi
Phase Ratio	1φ		0.041						0.062		λ
	2φ			0.886						0.000	1.302
	3φ	-				0.284				0.284	
	4φ						0.070			0.070	>0.844
Effective Green Time (s)	1φ		16.0						16.0		Cycle Time (s)
	2φ			33.0						33.0	
	3φ	16.0				16.0					90
	4φ						21.0				
Capacity Ci		0	617	812	3,406	338	424	1,800	356	930	
Volume-to-Capacity Ratio q/Ci		-9,999.000	0.230	2.092	0.532	1.595	0.342	0.224	0.348	0.002	
Judgement		OK	OK	NG	OK	NG	OK	OK	OK	OK	
Queue Length Ls (m)				382.7			42.2			0.7	

Worst VCR

Evaluation of Intersections and Prioritization of Improvement Projects

✓ *Volume to Capacity Ratio (VCR) in Current Situation*

(2) Unsignalized Intersection (Case: S09-32, 2022, Worst VCR=6.16)

No	Traffic Mn	Qx	gx	hx	Capacity C _{px}	Difference C _{px} -Mn	Ratio Mn / C _{px}	Judgement
1	292	0.419	4.1	2.2	450	158	0.649	OK
2	949	0.359	6.9	3.3	154	-795	6.162	NG
3	51	0.696	7.5	3.5	14	-37	3.643	NG

Worst VCR

Evaluation of Intersections and Prioritization of Improvement Projects

✓ Volume to Capacity Ratio (VCR) in Current Situation

(3) Roundabout (Case: S02-8, 2030, Worst VCR=1.02)

Step 10. Determine LOS for each lane on each approach

Step 8. Compute the volume-to-capacity ratio for each lane

$$x_i = v_i / c_i$$

x_i : volume-to-capacity ratio of the subject lane i

v_i : demand flow rate of the subject lane i (veh/h)

c_i : capacity of the subject lane i (veh/h)

x_{bypass} : volume-to-capacity ratio of the bypass lane i

	SB	WB	NB	EB
$x_{i,R}$	0.97	0.82	0.56	0.79
$x_{i,L}$	1.02	0.86	0.58	0.87
x_{bypass}	-	-	-	-

Worst VCR

Step 9. Compute the average control delay for each lane

$$d = 3600 / c + 900T * (x - 1 + ((x - 1)^2 + (3600 * x / c) / 450T))^{1/2} + 5 * \min[x, 1]$$

d : average control delay (s/veh)

x : volume-to-capacity ratio of the subject lane

c : capacity of the subject lane (veh/h)

T : time period (h) ($T = 0,25$ h for a 15-min analysis)

d_{bypass} : average control delay for bypass lane (s/veh)

	SB	WB	NB	EB
d_R (s/veh)	57.4	37.8	14.8	48.1
d_L (s/veh)	70.8	45.7	15.8	63.4
d_{bypass} (s/veh)	0.0	0.0	0.0	0.0

Control Delay	$v/c \leq 1.0$	$v/c > 1.0$
0 - 10	A	F
> 10 - 15	B	F
> 15 - 25	C	F
> 25 - 35	D	F
> 35 - 50	E	F
> 50	F	F

	SB	WB	NB	EB
LOS_R	F	E	B	E
LOS_L	F	E	C	F
LOS_{bypass}	-	-	-	-

Step 11. Compute the average control delay and determine LOS for each approach and the roundabout as a whole

$$d_{intersection} = \sum d_i v_i / \sum v_i$$

$d_{intersection}$: control delay of the entire intersection (s/veh)

d_i : control delay of approach (s/veh)

v_i : flow rate for approach i (veh/h)

	SB	WB	NB	EB
d_i	64.1	41.7	15.3	55.7
LOS_i	F	E	C	F
$d_{intersection}$	45.6			
$LOS_{intersection}$	E			

Evaluation of Intersections and Prioritization of Improvement Projects

✓ *Traffic Volume of Intersection*

Top 20 Intersections for Traffic Volume (Total Entry per Day)

Intersection Ranking for Traffic Volume

No.	Intersection No.	Intersection Name	Traffic Volume (Total Entry per Day, 2022)
1	S09-31	Gisozi	174,450
2	S02-8	Kanogo	150,105
3	S08-28	Chez Lando	140,023
4	S08-26	RDB	138,148
5	S04-15	Giporoso	134,298
6	S07-21	Medihill	133,776
7	S06-20	Sopetrade	131,822
8	S04-14	Sonatube	129,913
9	S07-22	Kimicanga	128,981
10	S01-3	Nyabugogo - Kimisagara	128,601
11	S08-29	KFC/Prince house	125,212
12	S03-10	Rwandex - Gitwaza	123,795
13	S03-9	Rwandex -SP	121,211
14	S03-11	Rwandex - Magerwa	119,956
15	S08-24	University of Kigali	118,350
16	S06-18	Muhima	116,404
17	S01-2	Nyabugogo - Gatsata	111,416
18	S03-12	Rwandex - Gikondo	110,441
19	S08-25	Convention Center East	108,547
20	S05-16	Kucyamitsingi	108,363

Evaluation of Intersections and Prioritization of Improvement Projects

✓ *Volume of NMT*

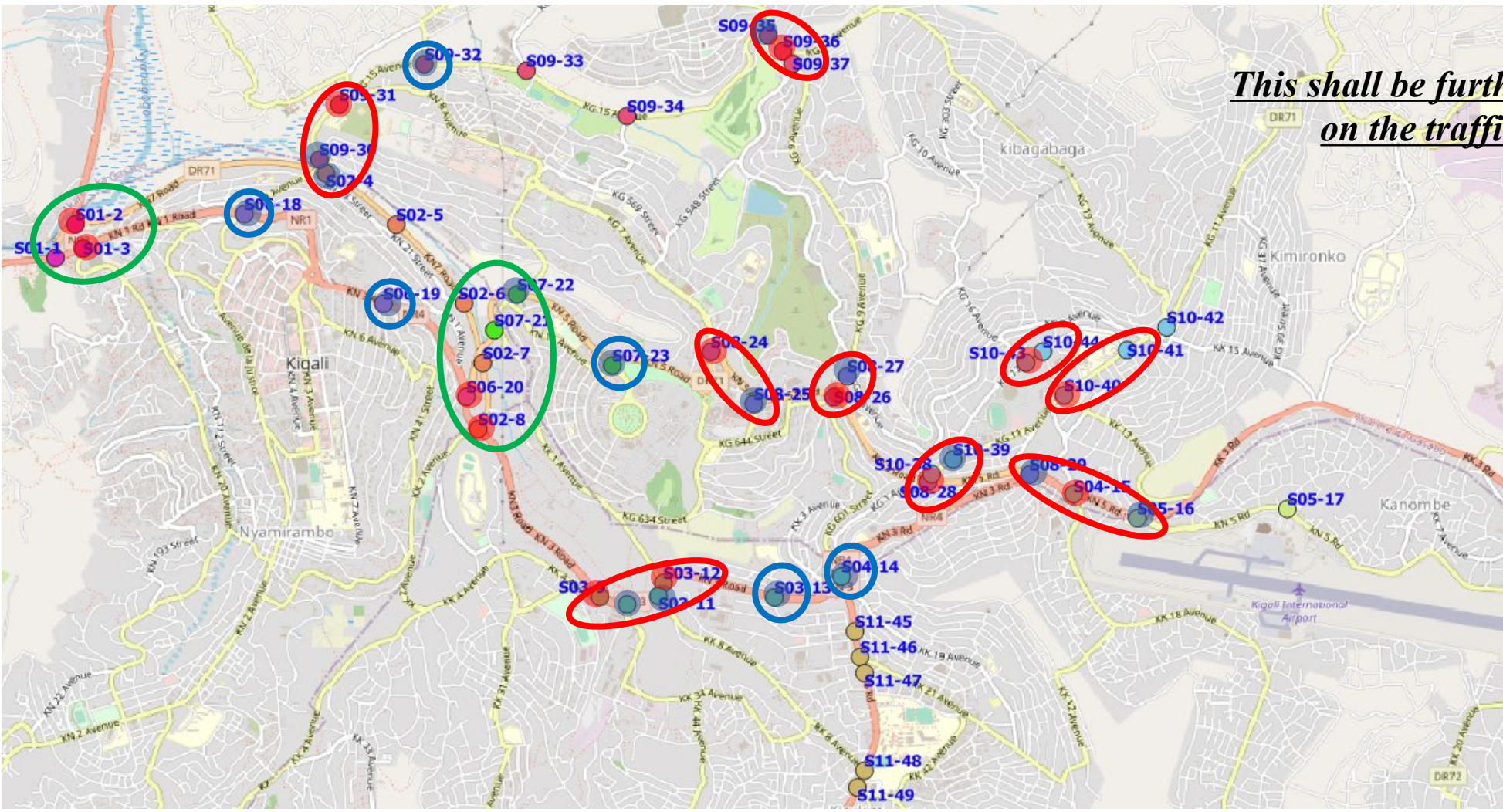
Intersections with Large Volume of NMT

No.	Intersection No.
S01-1	Nyabugogo - Ruyenzi
S01-2	Nyabugogo - Gatsata
S01-3	Nyabugogo - Kimisagara
S09-30	Kinamba-BK
S04-14	Sonatube
S04-15	Giporoso
S05-16	Kucyamitsingi
S08-26	RDB
S08-28	Chez Lando
S10-38	Gisimenti- Chez Lando
S10-39	Gisimenti - Airtel
S09-35	Mukabuga Kanyarutarama - Airtel
S10-40	Kimironko - Kwarwahama
S10-41	Kimironko - Simba
S10-42	Kimironko - BPR

No.	Intersection No.
S09-31	Gisozi
S02-7	Kwa Rasta2
S06-20	Sopetrade
S07-22	Kimicanga
S03-10	Rwandex - Gitwaza
S03-11	Rwandex - Magerwa
S03-13	To Ziniya Market
S08-29	KFC/Prince house
S06-18	Muhima
S06-19	Peage - RSSB
S07-23	Kukabindi
S08-24	University of Kigali
S08-25	Convention Center East
S08-27	RDB To Nyarutarama
S09-32	Gakinjoro
S09-33	Kumavaze - Vision City
S09-36	Hotel Villa Portofino Kigali
S10-43	Remera Control Technique
S10-44	Remera - REB
S11-46	Kicukiro - Simba
S11-50	Kicukiro - DMC




Evaluation of Intersections and Prioritization of Improvement Projects

✓ Necessity of Coordinated Signal Control (at Adjacent Intersections)





This shall be further considered based on the traffic survey result

Signal Control

-  :Area Control
-  :Coordinated Control
-  :Point Control

Sensor Type

-  :Key Intersection
 - Camera Type Sensor
 - Que Length Sensor
-  :Isolated/Important Intersection
 - Camera Type Sensor

Current Idea of Signal Control Method

Evaluation of Intersections and Prioritization of Improvement Projects

✓ *Necessity of Bus Priority (on DBL Pilot Route)*



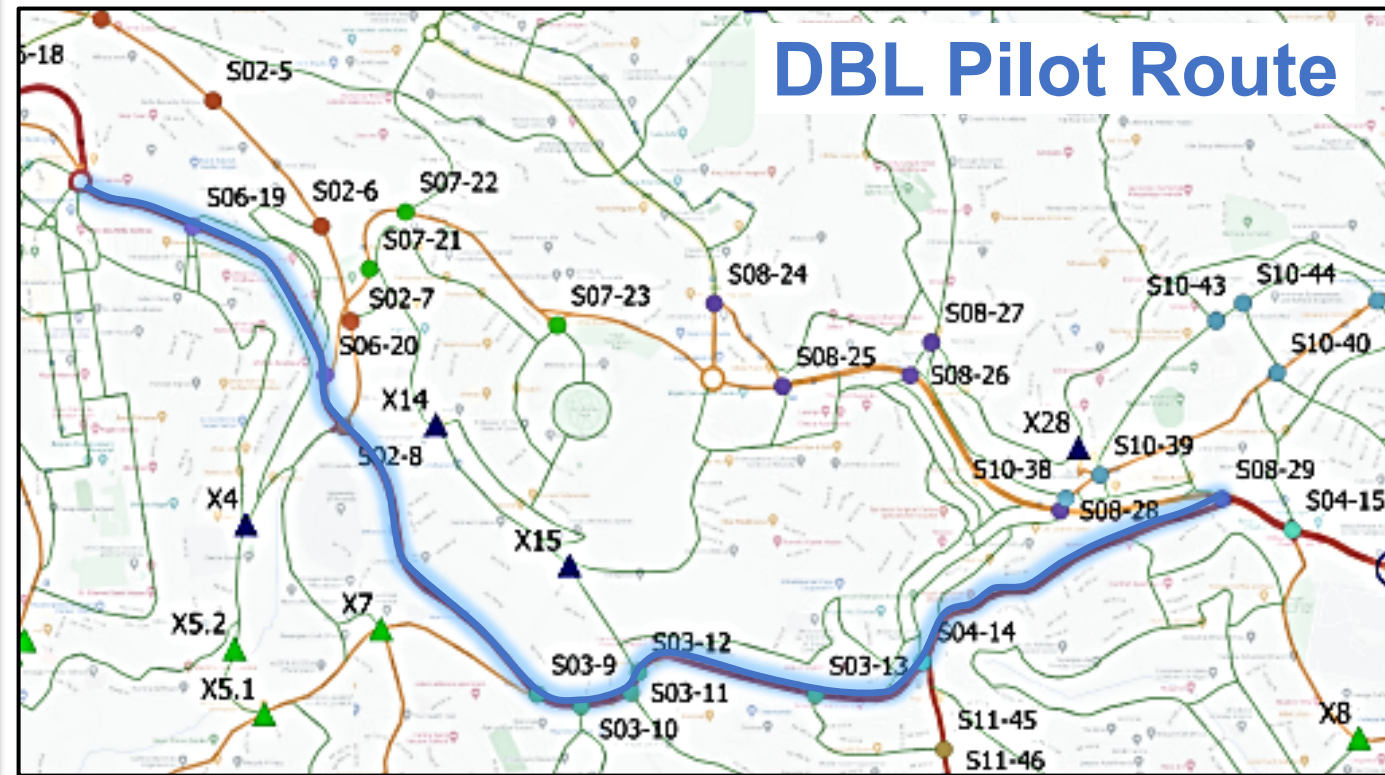
Kigali

Introduction of
Dedicated Bus Lanes

Final Report

V4-0

March 2022



Evaluation of Intersections and Prioritization of Improvement Projects

Evaluation Result (Emergency & Effectiveness (1/2))

IS No.	Name of IS	Evaluation						Sub Total Score
		Emergency			Effectiveness			
		Worst Value of VCR			Rating ^{*1} (High 3 -Low 1)	Traffic Volume ^{*2} (Total Entry per Day)	Rating ^{*3} (High 3 -Low 1)	
		2022	2025	2030	(A)	2022	(B)	
S01-1	Nyabugogo - Ruyenzi	1.18			3	78,429	2	5
S01-2	Nyabugogo - Gatsata				1	111,416	3	4
S01-3	Nyabugogo - Kimisagara				1	128,601	3	4
S02-4	Kinamba	1.21			3	100,390	3	6
S09-30	Kinamba-BK	1.65			3	101,353	3	6
S09-31	Gisozi	6.12			3	174,450	3	6
S02-6	Kwa Rasta1			1.41	2	76,892	2	4
S02-7	Kwa Rasta2		1.01		2	91,612	2	4
S06-20	Sopetrade	1.42			3	131,822	3	6
S07-21	Medihill	9.22			3	133,776	3	6
S07-22	Kimicanga	1.25			3	128,981	3	6
S02-8	Kanogo			1.02	2	150,105	3	5
S03-9	Rwandex -SP	1.19			3	121,211	3	6
S03-10	Rwandex - Gitwaza				1	123,795	3	4
S03-11	Rwandex - Magerwa	1.12			3	119,956	3	6
S03-12	Rwandex - Gikondo	12.71			3	110,441	3	6
S03-13	To Ziniya Market	4.98			3	99,756	2	5
S04-14	Sonatube			1.08	2	129,913	3	5
S04-15	Giporoso	1.03			3	134,298	3	6
S08-29	KFC/Prince house			1.13	2	125,212	3	5
S05-16	Kucyamitsingi	3.71			3	108,363	3	6
S05-17	Kanombe/Airport Entrance				1	66,351	2	3
S06-18	Muhima		1.10		2	116,404	3	5
S06-19	Peage - RSSB	1.37			3	78,143	2	5
S07-23	Kukabindi		2.11		2	26,204	1	3
S08-24	University of Kigali		1.01		2	118,350	3	5
S08-25	Convention Center East	1.00	1.11		3	108,547	3	6

Evaluation of Intersections and Prioritization of Improvement Projects

Evaluation Result (Emergency & Effectiveness (2/2))

IS No.	Name of IS	Evaluation						
		Emergency				Effectiveness		Sub Total Score
		Worst Value of VCR			Rating ^{*1} (High 3 -Low 1)	Traffic Volume ^{*2} (Total Entry per Day)	Rating ^{*3} (High 3 -Low 1)	
		2022	2025	2030	(A)	2022	(B)	
S08-26	RDB	1.31			3	138,148	3	6
S08-27	RDB To Nyarutarama	1.23			3	62,010	2	5
S08-28	Chez Lando			1.13	2	140,023	3	5
S10-38	Gisimenti- Chez Lando		1.67		2	90,698	2	4
S10-39	Gisimenti - Airtel		3.33		2	103,543	3	5
S09-32	Gakinjiro	6.16			3	93,755	2	5
S09-33	Kumavaze - Vision City				1	72,515	2	3
S09-34	TV1				1	51,466	2	3
S09-35	Mukabuga Kanyarutarama - Airtel		2.63		2	87,343	2	4
S09-36	Hotel Villa Portofino Kigali	3.33			3	97,340	2	5
S09-37	White Stone APT		1.01		2	60,689	2	4
S10-40	Kimironko - Kwarwahama		1.68		2	48,396	1	3
S10-41	Kimironko - Simba	1.66			3	42,406	1	4
S10-42	Kimironko - BPR				1	74,406	2	3
S10-43	Remera Control Tecnique	1.53			3	4,907	1	4
S10-44	Remera - REB		5.26		2	4,907	1	3
S11-46	Kicukiro - Simba 信号設置済				1	68,565	2	3
S11-50	Kicukiro - DMC			2.13	2	35,726	1	3

Note *1) 3 points: VCR>1 as of 2022, 2 points: VCR>1 as of 2025/2030, 1 point: VCR<1 as of 2030
 *2) Traffic Volume of S10-43 is used even for S10-44 because traffic volume of S10-44 is not available.
 *3) 3 points: Traffic Volume>100,000, 2 points: Traffic Volume>50,000, 1 point: Traffic Volume<50,000
 *4) Additional 2 points for the intersection with much volume of NMT and 1 point for the intersectio with moderate volume of NMT.
 *5) Additional 2 points for the intersection where coordinated control is necessary and effective.
 *6) Additional 2 points for the intersections on the proposed DBL pilot route.

Evaluation of Intersections and Prioritization of Improvement Projects

Evaluation Result (Other Considerations & Priority Rank (1/2))

IS No.	Name of IS	Evaluation										
		Other Consideration			Total Score (G)= (C)+(D)+(E)+(F)	Total Score with Grouping (H)	Prioritization Result					
		Volume of NMT ^{*4}	Necessity for Coordinated Control ^{*5}	Necessity for Bus Priority ^{*6}			Priority Rank					
								1 10.0 -	2 10.0 - 8.6	3 8.5 - 6.1	4 6.0 - 3.1	5 - 3.0
(D)	(E)	(F)										
S01-1	Nyabugogo - Ruyenzi	2	2		9	8.3	3			✓		
S01-2	Nyabugogo - Gatsata	2	2		8					✓		
S01-3	Nyabugogo - Kimisagara	2	2		8					✓		
S02-4	Kinamba		2		8	9.0	2		✓			
S09-30	Kinamba-BK	2	2		10				✓			
S09-31	Gisozi	1	2		9				✓			
S02-6	Kwa Rasta1		2		6	8.3	3			✓		
S02-7	Kwa Rasta2	1	2		7					✓		
S06-20	Sopetrade	1	2	2	11					✓		
S07-21	Medihill		2		8					✓		
S07-22	Kimicanga	1	2		9					✓		
S02-8	Kanogo		2	2	9					✓		
S03-9	Rwandex -SP		2	2	10	10.0	1	✓				
S03-10	Rwandex - Gitwaza	1	2	2	9			✓				
S03-11	Rwandex - Magerwa	1	2	2	11			✓				
S03-12	Rwandex - Gikondo		2	2	10			✓				
S03-13	To Ziniya Market	1		2	8	8.0	3			✓		
S04-14	Sonatube	2		2	9	9.0	2		✓			
S04-15	Giporoso	2	2		10	9.3	2		✓			
S08-29	KFC/Prince houce	1	2		8				✓			
S05-16	Kucyamitsingi	2	2		10				✓			
S05-17	Kanombe/Airport Entrance				3	3.0	5					✓
S06-18	Muhima	1			6	6.0	4				✓	
S06-19	Peage - RSSB	1		2	8	8.0	3			✓		
S07-23	Kukabindi	1			4	4.0	4				✓	
S08-24	University of Kigali	1	2		8	8.5	3			✓		
S08-25	Convention Center East	1	2		9					✓		

Evaluation of Intersections and Prioritization of Improvement Projects

Evaluation Result (Other Considerations & Priority Rank (2/2))

IS No.	Name of IS	Evaluation										
		Other Consideration			Total Score (G)= (C)+(D)+(E)+(F)	Total Score with Grouping (H)	Prioritization Result					
		Volume of NMT ^{*4}	Necessity for Coordinated Control ^{*5}	Necessity for Bus Priority ^{*6}			Priority Rank					
							(D)	(E)	(F)	1 10.0 -	2 10.0 - 8.6	3 8.5 - 6.1
S08-26	RDB	2	2		10	9.0	2		✓			
S08-27	RDB To Nyarutarama	1	2		8				✓			
S08-28	Chez Lando	2	2		9	8.7	2		✓			
S10-38	Gisimenti- Chez Lando	2	2		8				✓			
S10-39	Gisimenti - Airtel	2	2		9				✓			
S09-32	Gakinjiro	1			6	6.0	4				✓	
S09-33	Kumavaze - Vision City	1			4	4.0	4				✓	
S09-34	TV1				3	3.0	5					✓
S09-35	Mukabuga Kanyarutarama - Airtel	2	2		8	7.3	3			✓		
S09-36	Hotel Villa Portofino Kigali	1	2		8					✓		
S09-37	White Stone APT		2		6					✓		
S10-40	Kimironko - Kwarwahama	2	2		7	7.5	3			✓		
S10-41	Kimironko - Simba	2	2		8					✓		
S10-42	Kimironko - BPR	2			5	5.0	4				✓	
S10-43	Remera Control Technique	1	2		7	6.5	3			✓		
S10-44	Remera - REB	1	2		6					✓		
S11-46	Kicukiro - Simba 信号設置済	1			4	4.0	4				✓	
S11-50	Kicukiro - DMC	1			4	4.0	4				✓	
Note	*1) 3 points: VCR>1 as of 2022, 2 points: VCR>1 as of 2025/2030, 1 point: VCR<1 as of 2030				Number of Intersections in Each Rank			4	12	20	7	2
	*2) Traffic Volume of S10-43 is used even for S10-44 because traffic volume of S10-44 is not available.				Accumulated Number			4	16	36	43	45