CNI 세미나 2019-073

해외 교통전문가 세미나

- 도시가로 교통시스템 구축과 차량주행거동 기반 교통안전도 해석 -

주최·주관 : 충남연구원 공간·환경연구실

일시 : 2019년 8월 7일(수) 09:30

장소 : 충남연구원 4층 세미나실

진행순서

09:30~09:40 개회 및 참석자 소개 (사회 : 김원철 연구위원)

09:40~11:00 주제 발표

Prof. Liu Bohang (Shijiazhuang Tiedao University, China)
"Traffic System Construction of Clustered City with Narrow and Long Main District"
Prof. Kang Xuejian (Shijiazhuang Tiedao University, China)
"Analysis of Vehicle Maneuverability and Driver Characteristics on a Curved Road"

11:00~12:00 토론 (좌장: 김원철 연구위원)

도명식 교수 (한밭대학교 도시공학과)
김정화 책임연구원 (국토연구원 국토인프라연구본부)
이정범 책임연구위원 (대전세종연구원 도시기반연구실)
오상진 선임연구위원 (충북연구원 공간창조연구부)
김형철 책임연구원 (충남연구원 공간환경연구실)

12:10~12:20 폐회 및 정리

Traffic system construction of clustered city with narrow and long main district

Bohang Liu
Shijiazhuang Tiedao University

2019.08

CONTENTS

01 Compilation background and Traffic location

1.1 Compilation background

1.2 Traffic location

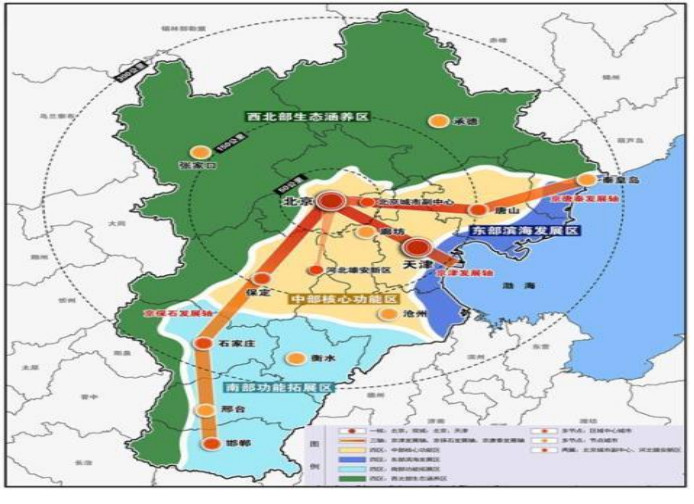
01 Compilation background and Traffic location

1.1 Compilation background

- The national and provincial multi-level development strategy defines the positioning of Zhangjiakou regional node city, and it is necessary to improve the transportation network and major traffic collection and distribution transportation system.

- ✓ The border of Beijing, Hebei, Jin and Mongolia provinces
- ✓ North west of Beijing-Tianjin-Hebei town group.
- ✓ The "North Gate" of the Capital
- ✓ Jointly construct "Hebei New Wing" with Xiongan New District, one of the two districts of "Capital"

Cities with important nodes in the Sino-Mongolian-Russian Economic Corridor



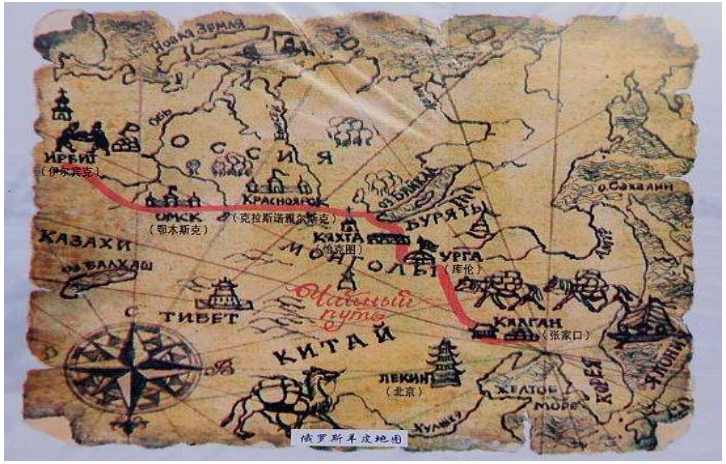
the coordinated development of the Beijing-Tianjin-Hebei region

1.2 Traffic location

A traffic fortress from ancient times to the present

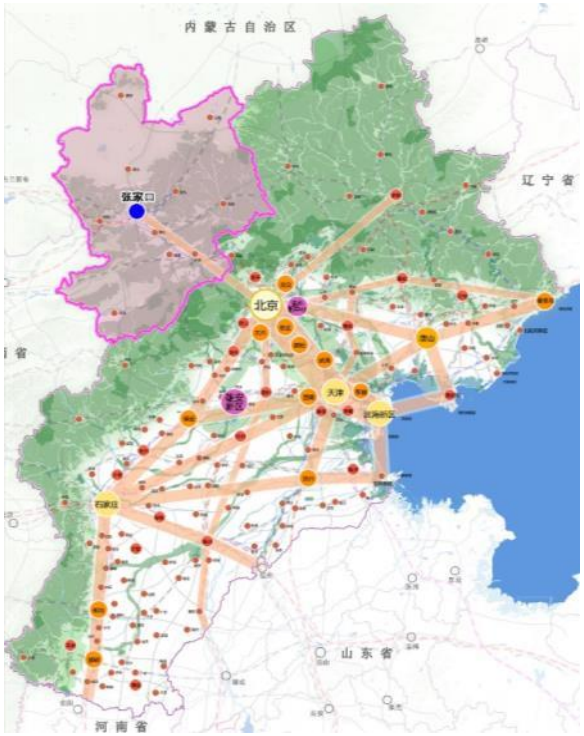
"Zhang Ku Avenue" starting point city. In the national "One Belt and One Road" strategy, Zhangjiakou is located in the "Sino-Russian Economic Corridor" of the six economic corridors.

- ✓ It is the intersection of Beijing-Tianjin-Hebei (Bohai Rim) economic circle and Ji Jin-Meng (outer Great Wall) economic circle.



Zhang Ku Avenue

"One Belt and One Road" and " Wu Dazhang " Cooperation Zone



Beijing-Tianjin-Hebei integration

02 Current Traffic Achievement and deficiency

2.1 Regional Traffic Achievement and deficiency

2.2 Urban Traffic Achievement and deficiency

02 Current Traffic Achievement and deficiency

2.1 Regional Traffic Achievement and deficiency

Affected by terrain, external contacts rely too heavily on land traffic, but the service level is low, and the contact time is more than 3 hours.

■ **To Beijing（ Capital, Beijing-Tianjin-Hebei urban agglomeration core city ）**

connection	transport facilities	mileage (km)	time consuming (h)
Ordinary railway	Jingbao railway	190	3-4
freeway	Beijing-Tibet Expressway, Jingxin Expressway	220	3-4
General national highway	G110、G109	210	4-5

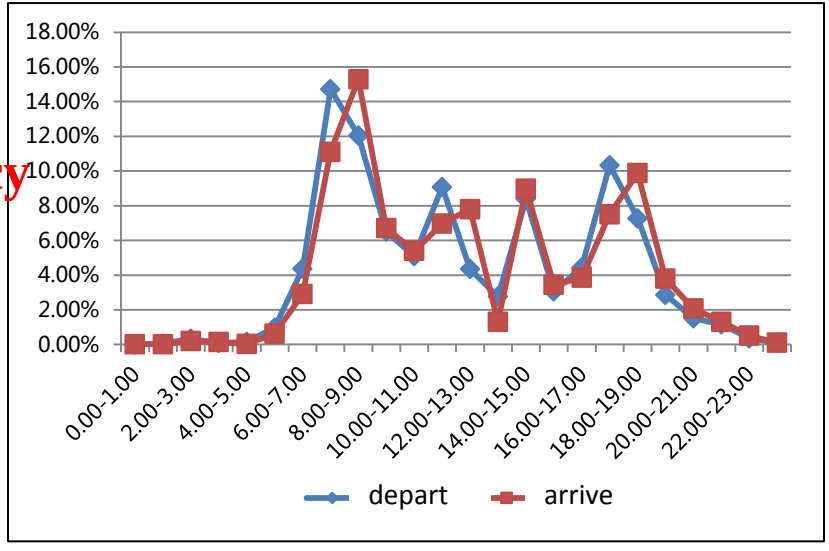
Layout of facilities for Zhangjiakou and Beijing contact channels

2.2 Urban Traffic Achievement and deficiency

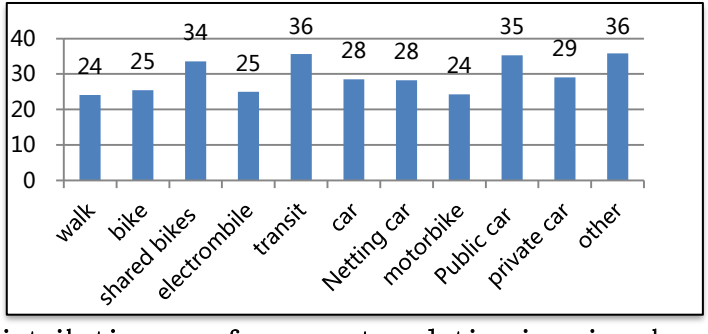
2.2.1 basic feature

Residents travel: showing four peaks, there are two small peaks at noon; green travel is the main body, public transport is slightly higher than cars.

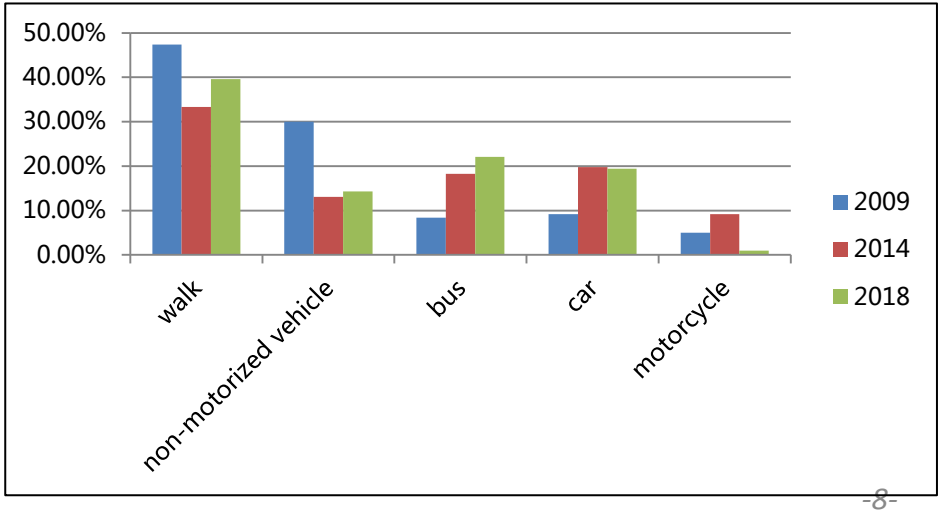
- ✓ The average travel distance of residents is **3.09km.**
- ✓ The average travel time of the residents is **28 minutes.**
- ✓ The average number of trips is **2.8 times.**



Travel time distribution map



Distribution map of average travel time in main urban area



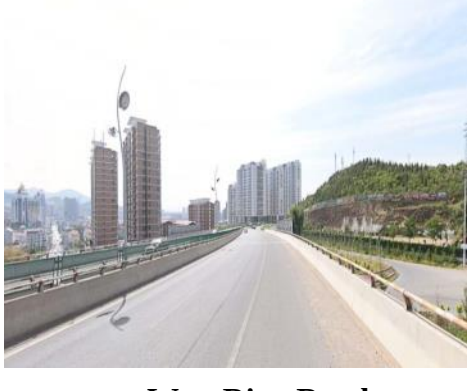
Travel structure comparison chart

2.2.2 Traffic Achievement and deficiency

- **Urban road**
  - **main urban road**

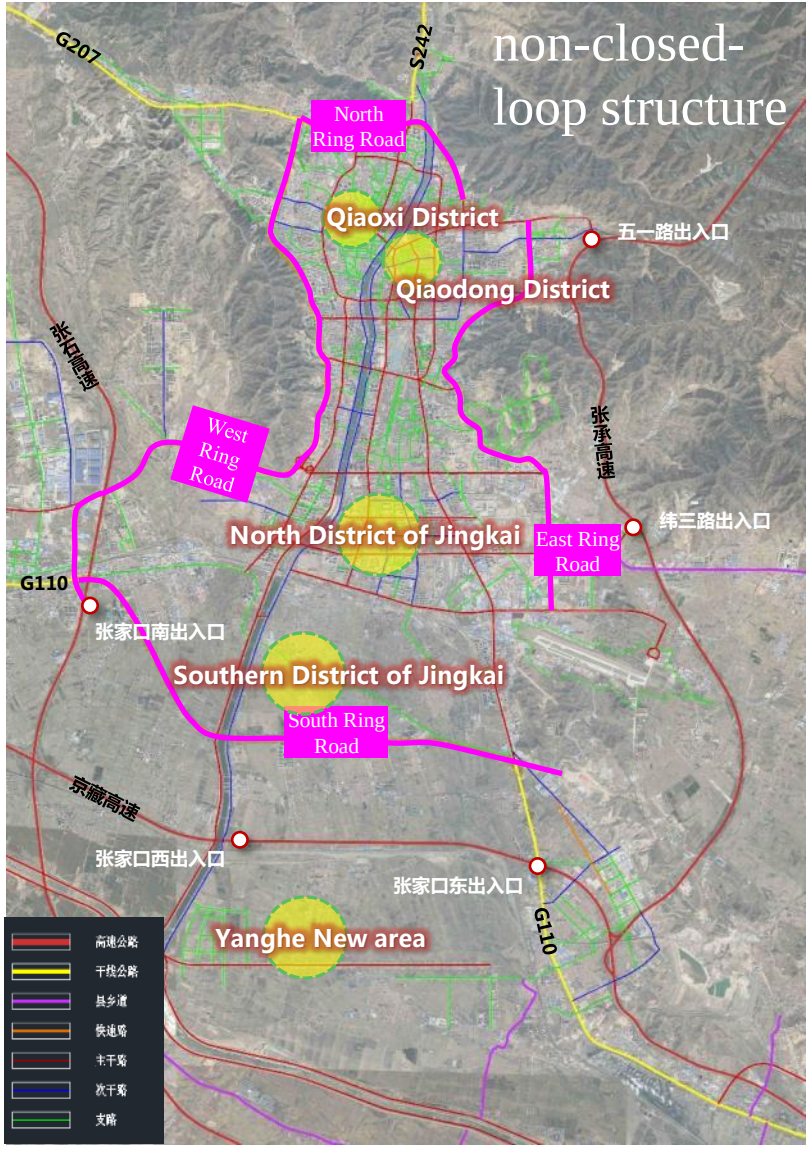
Expressway: basically form a fast loop, effectively support the framework of urban spatial development.

- ✓ **With the highway, the main road connection is not smooth.**
- ✓ **The connection with the main road is not enough.**
- ✓ **There is a lack of fast contact roads between east and west.**



West Ring Road

North Ring Road



03 Future traffic forecast

Urban traffic forecast

03 Future traffic forecast

- Urban traffic forecast

	status quo（2017）		The forward（2035）
Main urban population：	664000	➔	1.15 million
Total travel volume ：	1.86 million times	➔	3 million ~ 3.1 million
Travel distance：	3.09 km	➔	4 ~ 4.5 km
Private cars：	110,000 vehicles	➔	335,000 vehicles

Thousands of people possess：181 vehicles / thousand people ➔ 291 vehicles / thousand people

Bus and car motorized travel competition has entered an extremely sensitive and critical period. The downward pressure on the bus has increased.

Cross-district travel in the main city and wanquan and xuanhua increased further.

Main city interior north-south direction (bridge west bridge east and Economic Development Zone) travel proportion further increased.

04 Planning strategy system

Traffic system construction

王聃

Traffic system construction

Regional transportation system

- National level
- The high-speed rail +aviation

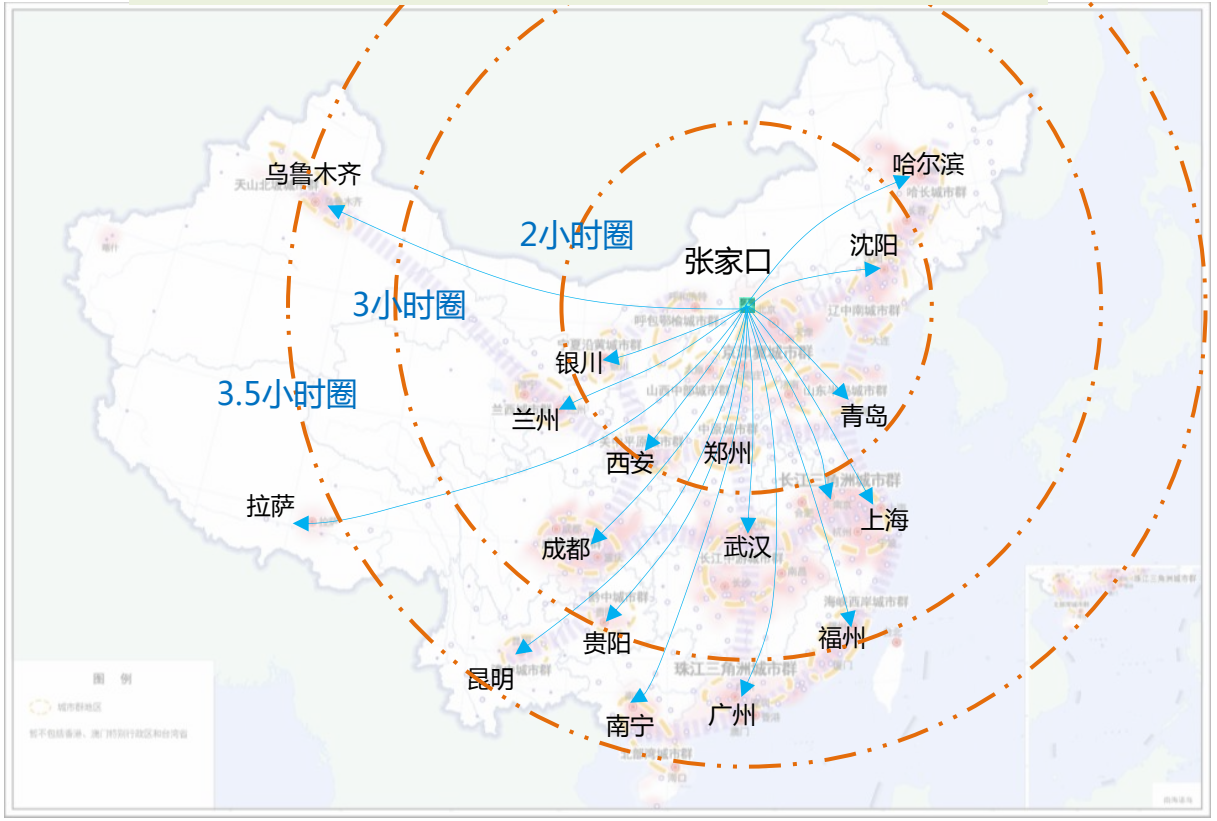
- Beijing-tianjin-hebei coordinated development zone +Surrounding provinces and cities
- Intercity railway +Freight railway+The highway

王聃

Traffic system construction

- region：35-15-1Transportation system

3.5 hours aviation circle to the core cities of the country's city clusters

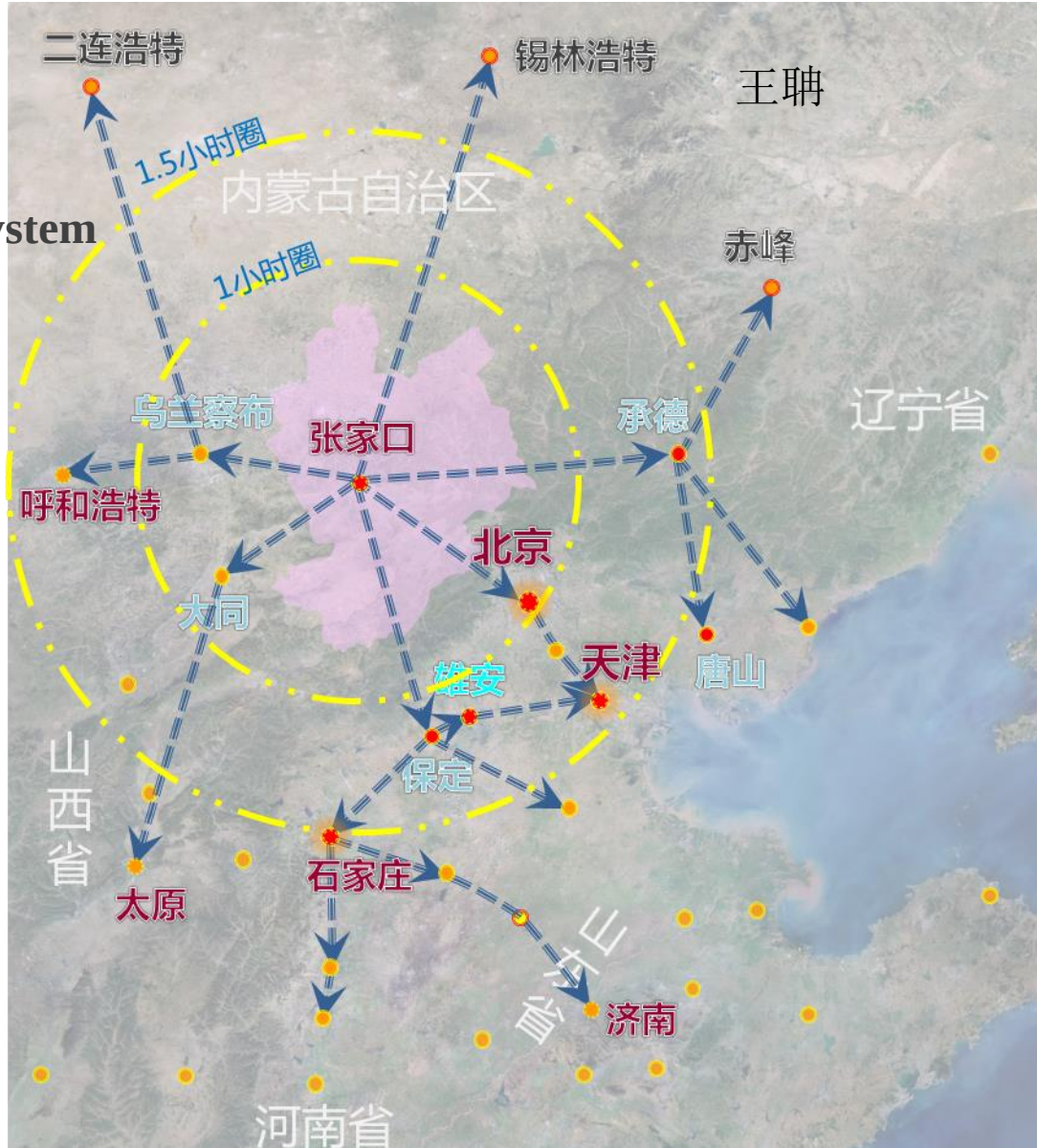


04 Planning strategy system

■ Traffic system construction

- region：35-15-1Transportation system

- ➢ 1.5 hours orbital circle to important cities and surrounding cities of Beijing, Tianjin and Hebei.
- ➢ 1 hour track circle to Beijing, Datong, Wulanchabu.



城际铁路

5.2 Winter Olympic Games and Tourism Transportation Planning

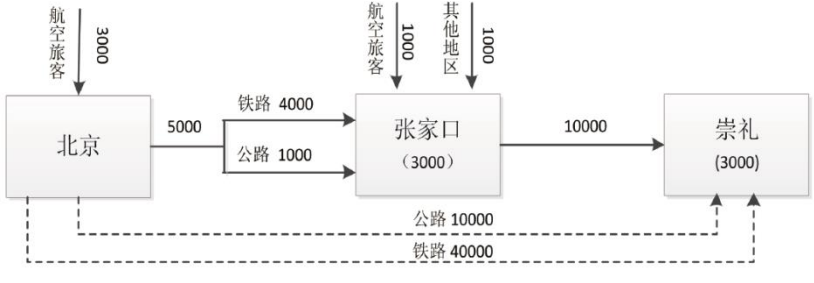
周愿

■ Transportation Linkage Planning for the Winter Olympic Games

1. Traffic Demand Forecast during Winter Olympic Games

Passenger Flow Composition: Members of the Olympic Family (including Olympic Committee and athletes, coaches, officials, etc.), Games staff, media reporters, volunteers, spectators, etc.

Passenger Flow Distribution：
Beijing – Yanqing - Chongli；
Zhangjiakou - Chongli；
Others - Zhangjiakou - Chongli。



Schematic diagram of the traffic flow induced by Winter Olympic Games

5.2 Winter Olympic Games and Tourism Transportation Planning

周愿

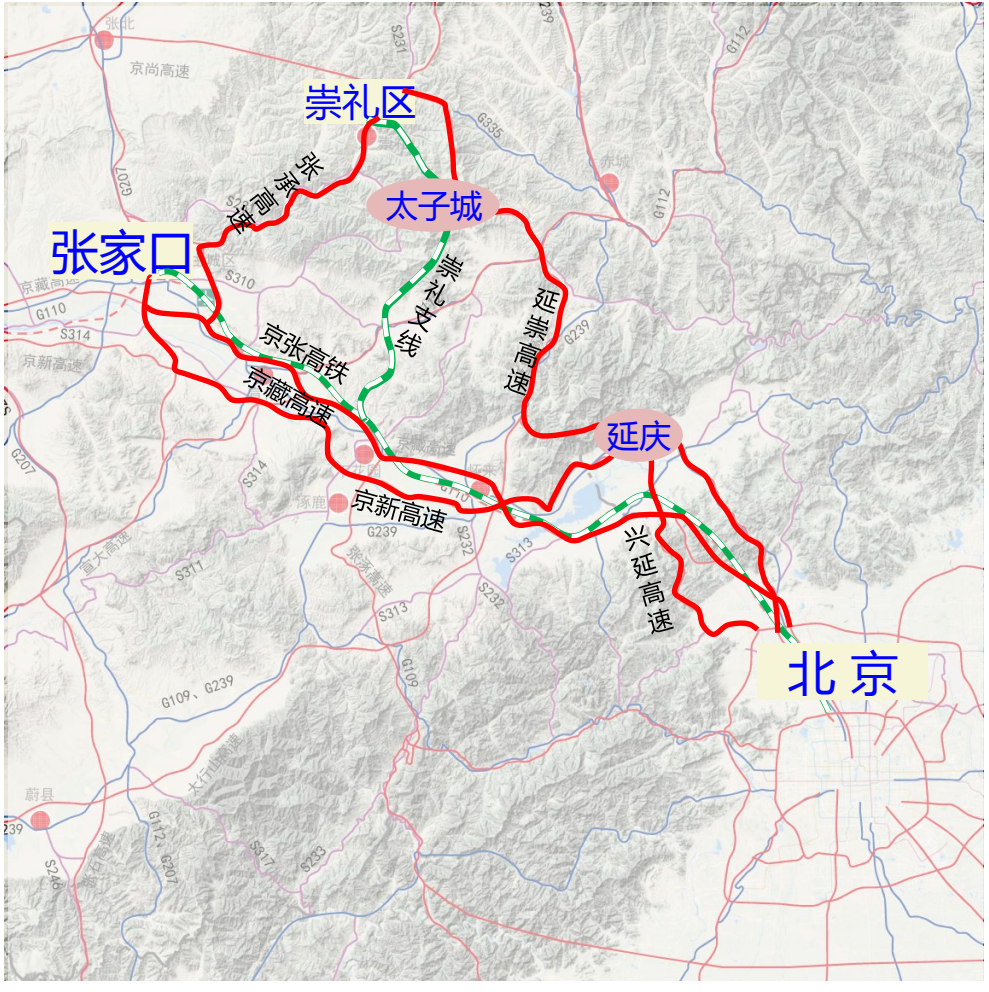
■ Transportation Linkage Planning for the Winter Olympic Games

2. Transportation corridors during Winter Olympic Games

Beijing - Chongli：
High Speed Railway：京张高铁——崇礼支线
Expressway：兴延高速—延崇高速

Beijing and other cities through zhangjiakou -- chongli：
High Speed Railway：京张高铁
Expressway：京藏高速、京新高速—张承高速

※Post-Olympic era: serveing the integration of Beijing and zhangjiakou, and build zhangjiakou Including chongli into the backyard garden and sports and leisure center of Beijing.



5.3 Urban backbone road network planning

1. New demands for Road Development

- **Optimizing and adjusting the Line position of trunk highways and diverting transit traffic**

G110 Line position optimization：

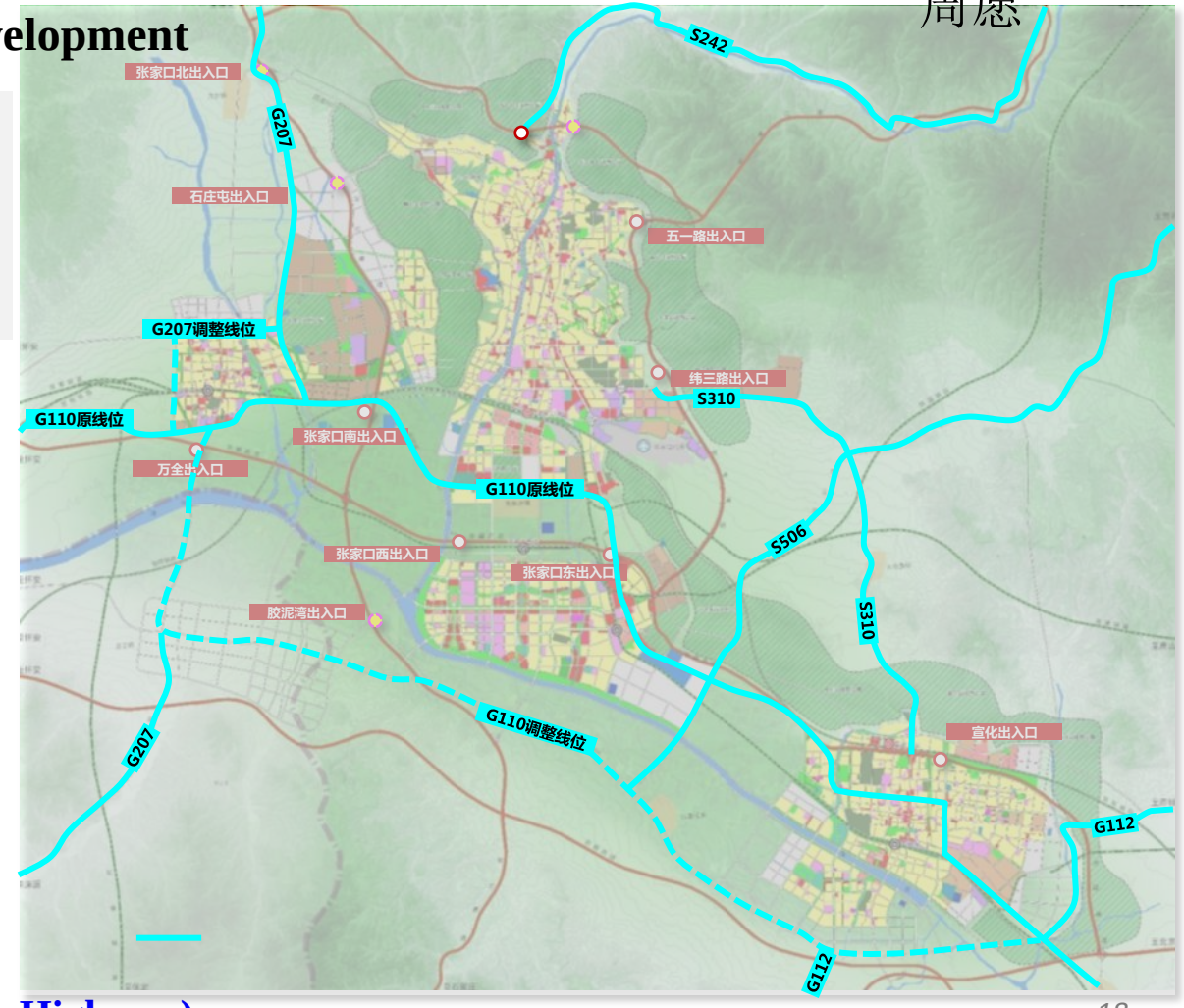
✓ 调整G110线位至洋河南侧，分流过境交通，释放既有线位功能服务城市交通；

G207 Line position optimization ：

✓ 调整G207经由万全区北环、西环接G110，进一步实现过境交通外绕，减少万全城市建设集中区分割；

S242 Line position optimization ：

✓ 调整S242入城段接北环线高速出入口。

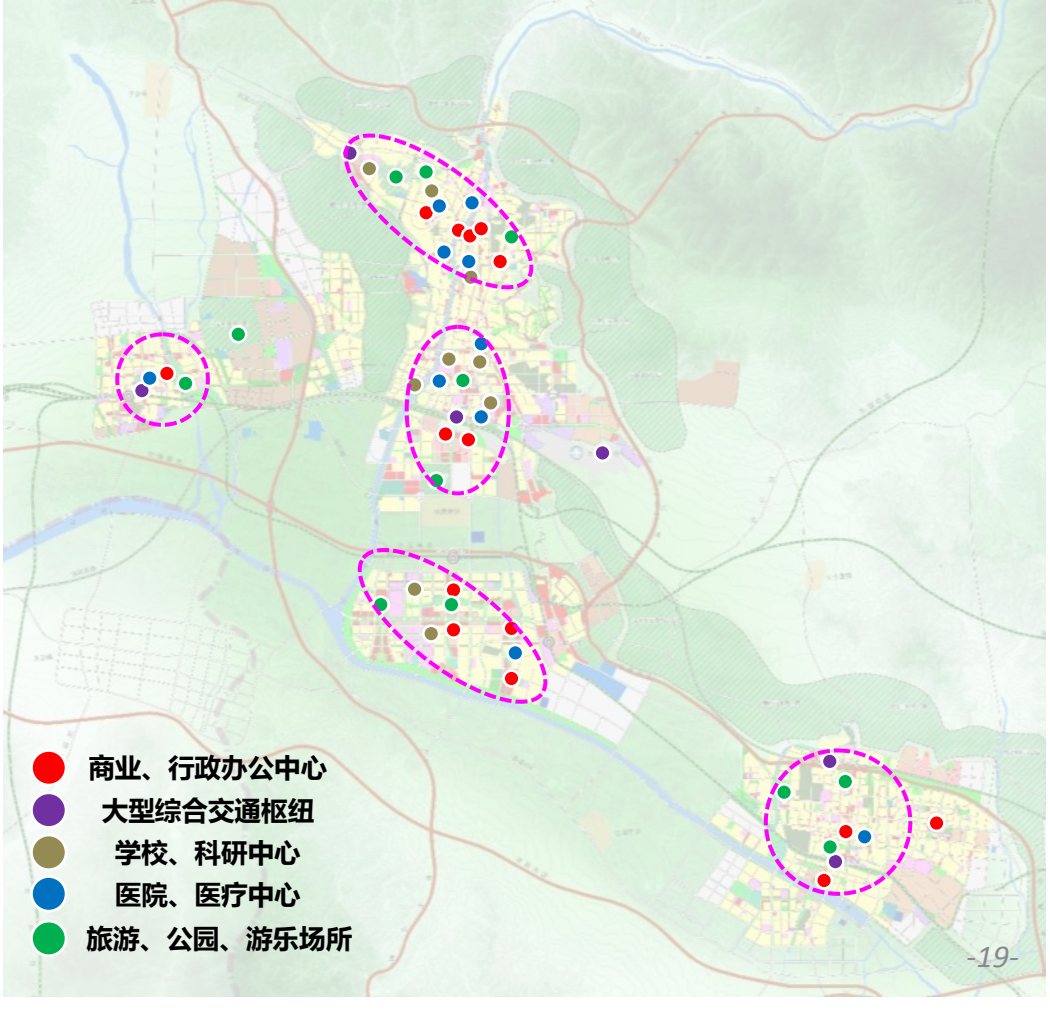


Upgrade X410 to S310 (First Class Highway)

5.4 Planning of urban public transport

Distribution Point Analysis of Passenger Flow

- The main passenger flow distribution points in Zhangxuanwan megalopolis are located in Qiaoxi, Qiaodong and Jingkai districts of the Zhangjiakou city.
- The main passenger flow distribution points in Wanquan District are around Minzhu Street.
- The main planning passenger flow distribution points in Yanghe new Disteict are around Zuanshixi street, Zhongxing street and Qinghe street
- The main passenger flow distribution points in Xuanhua district are in altstadt

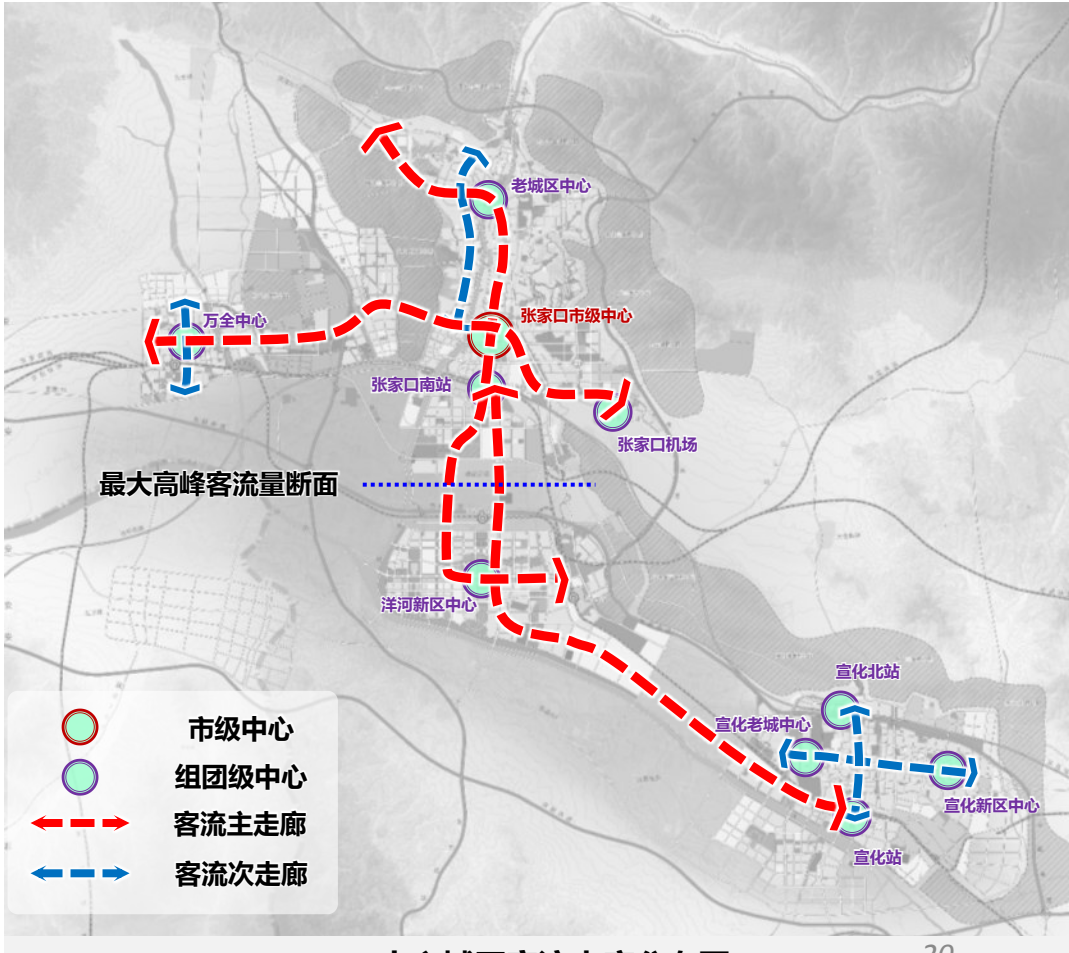


5.4 Planning of urban public transport

Prediction and Analysis of Passenger Corridor

- The scale of the North-South passenger corridor in the main urban area is relatively high
- There are two main passenger corridors in the main urban area to Wanquan and Xuanhua.
- The maximum peak cross-section passenger flow is 31,000 passengers per hour.

层级	中运量	城区轨道	区域城际
服务范围	主城区高强度、网络状客流走廊	中心城区高强度、高密度主要客流走廊	核心组团之间的快速直达联系
服务半径	15~20km	20-30km	30-300km
车站间距	0.8-1.0km	0.8-1.5km	10-20km
最高时速	60km/h	80km/h	200-250km/h
旅行时速	25km/h	40km/h	160-200km/h



中心城区客流走廊分布图

5.4 Planning of urban public transport

● Prospective Orbital Planning Scheme I

- The North-South Corridor uses the existing Beijing-Zhangjiakou railway to connect the old urban area, the city center, the South Railway Station Group and the Yanghe New Area.
- Strengthen the Northwest Passage of the Bridge to Connect the Airport Hub

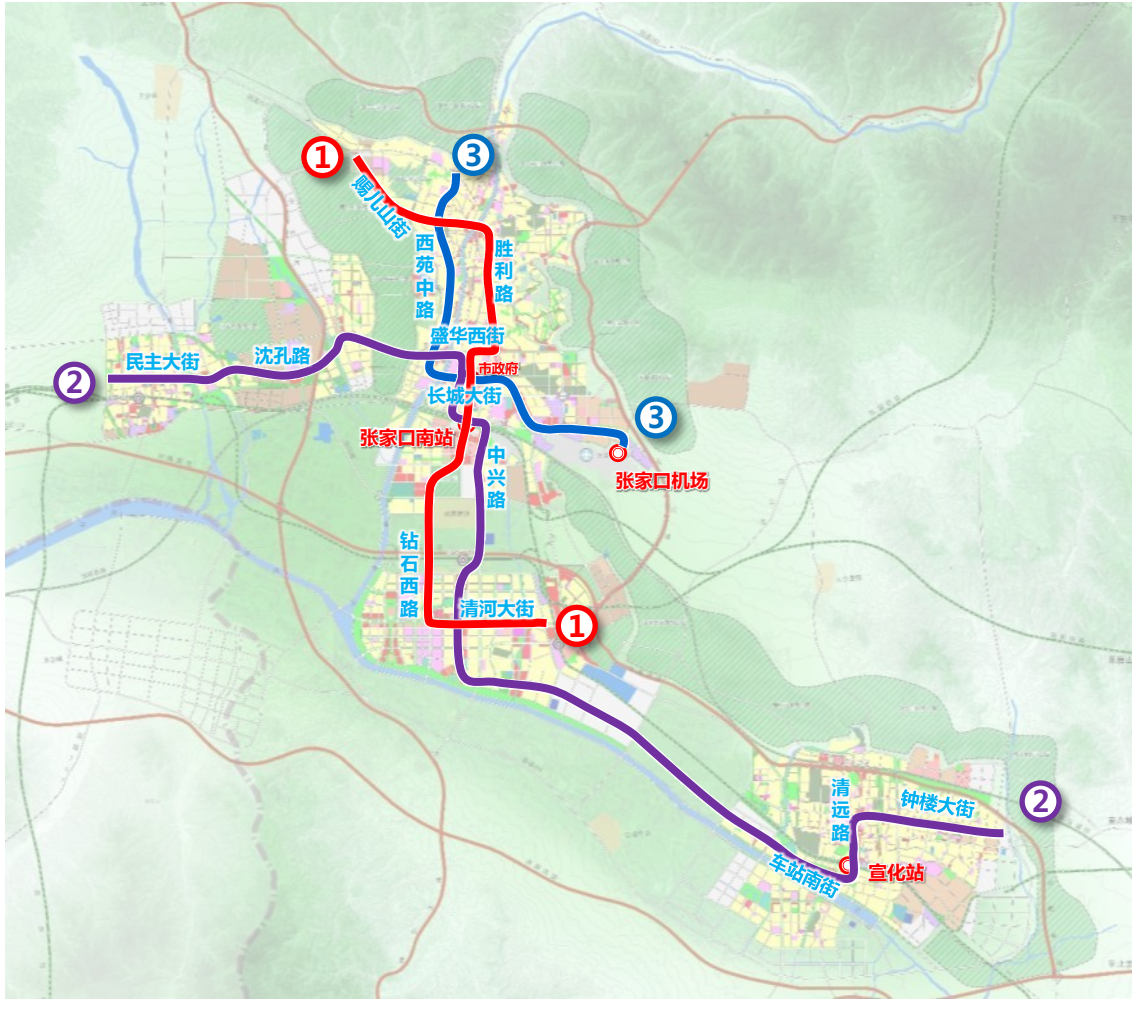
编号	起讫点	里程（km）
1号线	公路客运北站-沙岭子	29
2号线	万全-宣化	54.4
3号线	桥西-机场	17.8
合计		101.2
万人拥有轨道里程		0.511

5.4 Planning of urban public transport

- **Prospective Orbital Planning Scheme II**

- Strengthen the support of the North-South channel
- Metro Line 1 organize north-south passenger flow through Shengli Road
- Metro Line 2 Optimizes Shenghua West Street to South Station through Zuanshi Road, Zhanqian Street

编号	起讫点	里程（km）
1号线	公路客运北站-沙岭子	28
2号线	万全-宣化	54.8
3号线	桥西-机场	17.8
合计		100.6
万人拥有轨道里程		0.508



Report completed , Thank you !

Bohang Liu
Shijiazhuang Tiedao University
2019.08

Analysis of vehicle maneuverability and driver characteristics on a curved road

Kang Xuejian

Shijiazhuang Tiedao University

School of Traffic and Transportation Engineering

2019-08-07

• 1 Background

▲ Curved-road crashes can be seen as a result of the destruction of the harmonious combination of geometric characteristics. Failure to adjust for this obstruction can lead to vehicles leaving their lane or departing the roadway.

▲ The interaction between the driver and the vehicle maneuverability depends on how the driver processes the information coming from the road ahead and the surrounding environment, which are the most important sources of information for drivers

▲ The situation of the physiological information of the driver and maneuvering information of the vehicle can be used as effective indices for observing and evaluating the driving environment.

▲ The aim of this study is to suggest ways to enhance driving safety by determining how continuous curved roads (having more than two consecutive curves with no transition road in between) influences the driving behavior and vehicle maneuvers, and then identify the impact of these curves on the driver.

• 2 Conceptual Framework

▲ The current study extends SEM by introducing four new factors—road geometry, visual information, workload, and driving characteristics—according to the different road conditions.

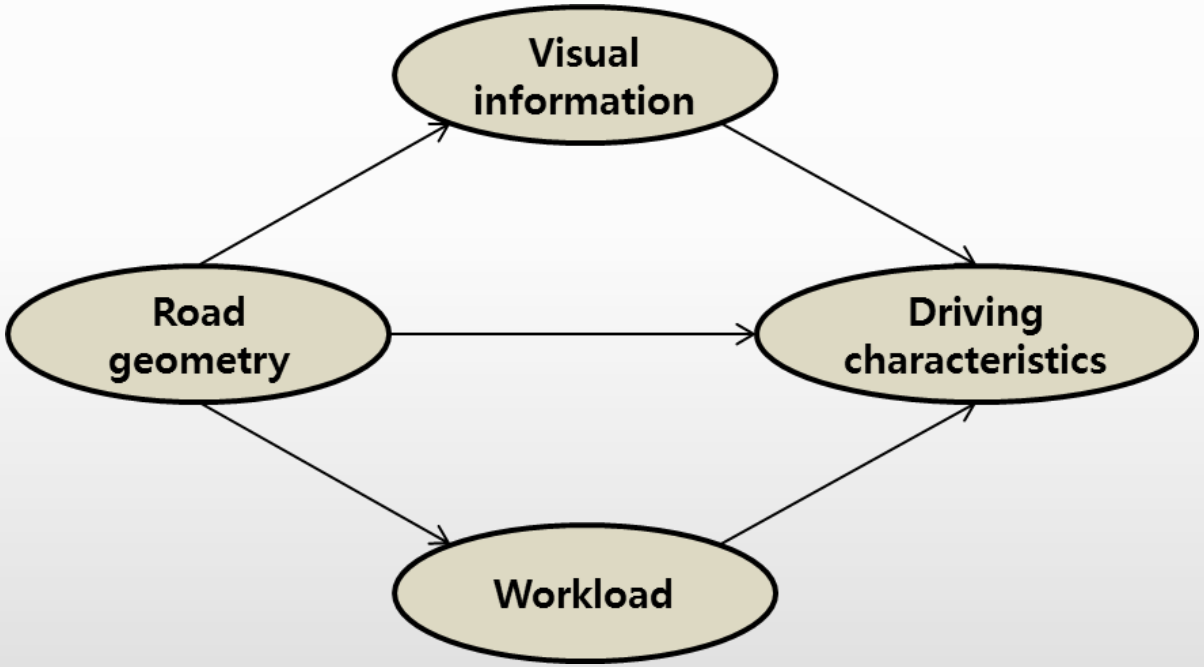


Fig.1 Structural model of driving characteristics and vehicle maneuvers.

Shijiazhuang Tiedao University
Kang Xuejian
2019-08-07

• 3 Methods - Driving simulation experiments

Participants

-14 male and 14 female with different occupations.

-15 had traffic accident experiments.

-9 had driving simulation experiments.

-Participants were good sound and emotional status.

Apparatus

-The virtual reality driving simulator (by Korea Expressway Corporation)

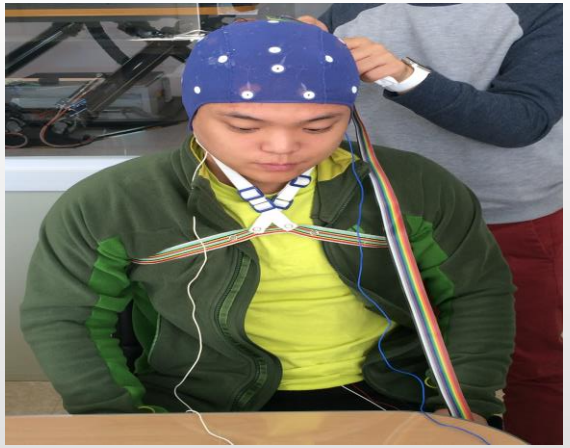
-Road–driver–vehicle interaction

-Brainwave testers & Face-LAB

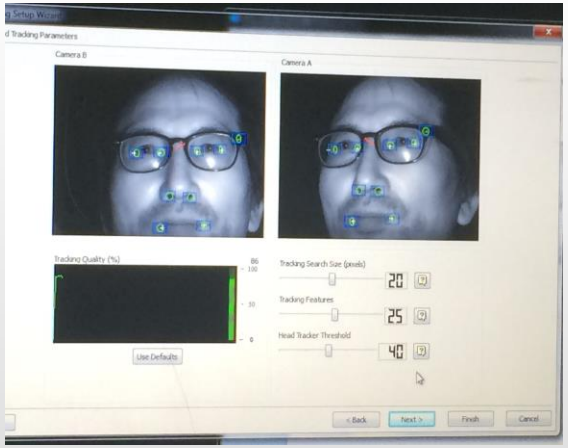
-Three-dimensional (3D) computer graphics with 3D view module

(a). Virtual driving simulator

(b). Driving situation



(c). Participants & brainwave testers



(d). Face-LAB

Fig.2 Laboratory apparatus

Shijiazhuang Tiedao University
Kang Xuejian
2019-08-07

• 3 Methods - Driving simulation experiments

Driving scenarios

-Area: Singal JC (61.2 km) to
Incheon IC (65.4 km) of
the Yeongdong Expressway

-Lane: three-lane roadway (3.6 m/lane)

-Traffic volume: 1500 vph

-Speed: 50-110 km

-Apparent distance: 500 m

-2 left curves, 3 right curves

-9 information recording points

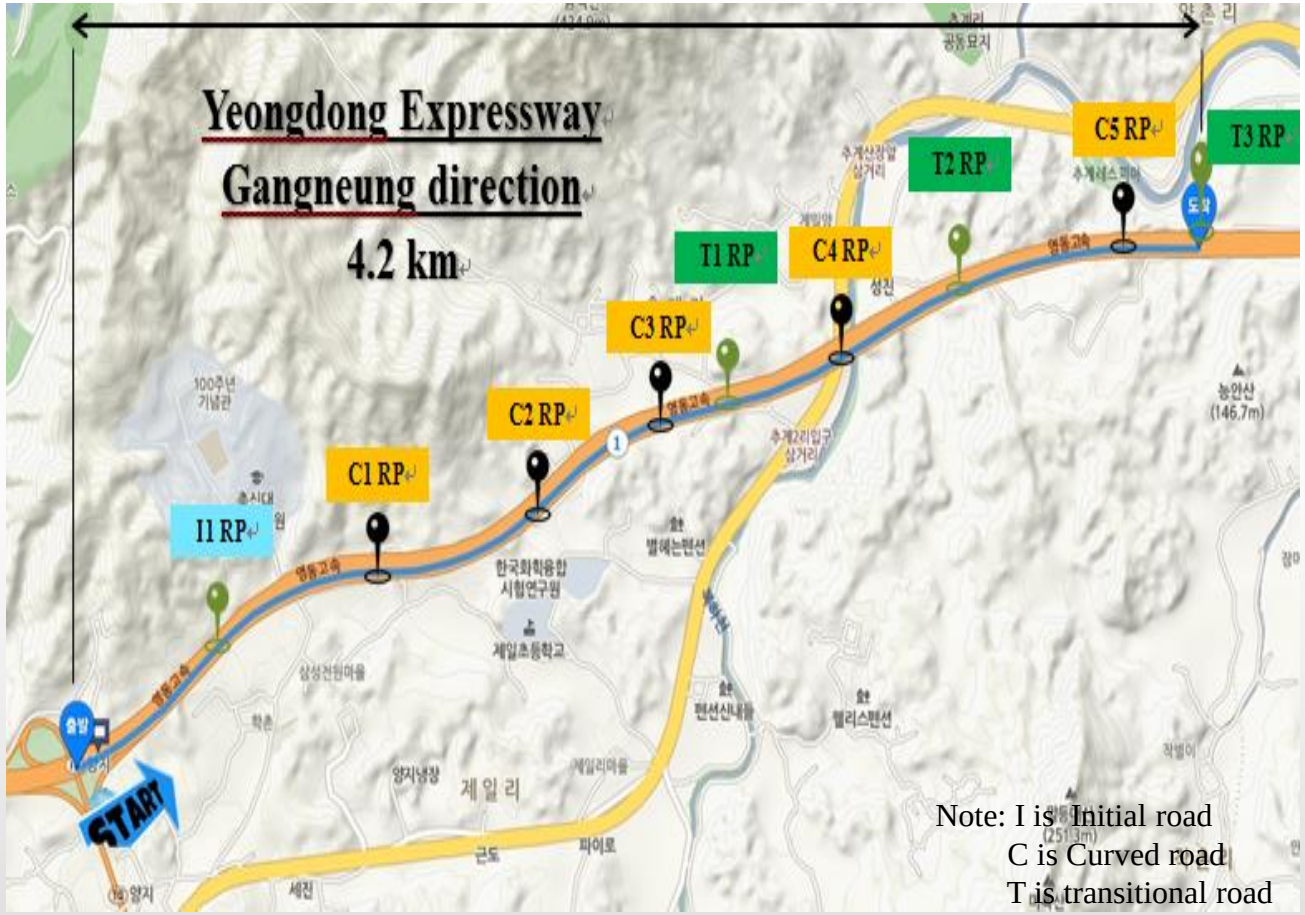


Fig.3 Driving scenarios

Shijiazhuang Tiedao University
Kang Xuejian
2019-08-07

• 4 Data Acquisition

▲ EEG measures

• EEG signals were sampled at 250 Hz. The EEG was measured using an electro-cap with 64 tin electrodes. Portilab 2 software was used to record all EEG signals. Starting from the raw EEG signals, the sampled EEG data was first high-pass filtered. The corrected data segments were then exported into binary files. The EEG was band-passed filtered in the frequency domain (FFT filter) of interest, using an edge frequency of 1 Hz below and above the lower and upper frequency band limit respectively. The first and last 10% of the epochs were omitted.

▲ Eye behavior

• The analyses in this paper were undertaken employing various combinations of the filters below, as defined in subsequent sections:

Rule 1: the Face-LAB automated gaze quality indices were reported as valid samples of eye position.

Rule 2: the Face-LAB did not classify the sample as blinking.

Rule 3: the Face-LAB did not classify the sample as saccade.

Rule 4: the sample gaze point intersected with a defined driving environment object.

Rule 5: the estimated gaze point was within a bounding box subtending ±1.5 m horizontally and ±1.0 m vertically.

Rule 6: the gaze point occurred within a group of at least 5 valid contiguous points.

• 5 Data Analysis

Dependent variables	Speed (km/h)	Acceleration (%)	Radius (100m)	LPE (m)	Gazing (%)	UFOV (˚)	Workload-Frontal lobe (%)	Workload-Temporal lobe (%)	Workload-Parietal lobe (%)	Workload-Occipital lobe (%)
	Mean (S. D)	Mean (S. D)	Mean (S. D)	Mean (S. D)	Mean (S. D)	Mean (S. D)	Mean (S. D)	Mean (S. D)	Mean (S. D)	Mean (S. D)
Initial road	49.67 (9.94)	37.19 (2.09)	19.19 (3.00)	.19 (.10)	2.65 (0.06)	66.90 (4.10)	47.84 (8.99)	67.82 (9.34)	88.76 (14.35)	52.88 (10.01)
Curved road 1	75.58 (5.68)	33.97 (6.73)	10.35 (3.45)	.25 (.12)	2.67 (0.08)	60.11 (3.53)	52.05 (11.53)	67.30 (11.58)	87.54 (11.74)	53.93 (12.44)
Curved road 2	88.04 (3.82)	20.18 (3.57)	9.47 (4.99)	.23 (.15)	2.77 (0.07)	56.45 (1.47)	54.58 (8.35)	71.88 (11.75)	91.06 (10.72)	56.11 (8.82)
Curved road 3	90.13 (1.15)	11.95 (2.30)	10.23 (3.94)	.31 (.17)	2.80 (0.08)	55.26 (1.55)	56.28 (12.26)	73.71 (9.79)	91.59 (11.40)	57.92 (10.63)
Transitional road 1	92.45 (0.60)	10.41 (0.38)	19.17 (5.36)	.13 (.07)	2.73 (0.05)	65.94 (2.06)	46.57 (10.63)	72.34 (10.63)	82.81 (9.54)	49.78 (5.16)
Curved road 4	89.12 (1.13)	8.67 (0.71)	13.86 (4.35)	.08 (.07)	2.79 (0.06)	63.91 (2.62)	57.24 (9.13)	82.84 (13.27)	99.16 (11.96)	61.11 (12.64)
Transitional road 2	91.30 (1.73)	14.41 (2.70)	19.53 (3.99)	.15 (.09)	2.69 (0.07)	64.32 (2.29)	54.88 (10.50)	78.05 (13.10)	95.30 (13.69)	55.32 (8.78)
Curved road 5	89.43 (1.82)	12.96 (3.41)	11.18 (6.31)	.31 (.15)	2.73 (0.06)	62.87 (2.74)	71.18 (11.02)	97.29 (13.13)	108.41 (12.17)	62.43 (11.45)
Transitional road 3	95.08 (2.04)	13.54 (2.14)	18.46 (4.76)	.14 (.11)	2.65 (0.09)	66.38 (3.27)	54.27 (15.61)	73.58 (15.86)	84.64 (14.72)	50.58 (10.06)

Table1. Basic descriptive statistics of the experiment road driver performance and vehicle performance

• 5 Data Analysis

	Speed	Acceleration	LPE	Gazing	UFOV	Workload-Frontal lobe	Workload-Temporal lobe	Workload-Parietal lobe	Workload-Occipital lobe
	T (Sig.)	T (Sig.)	T (Sig.)	T (Sig.)	T (Sig.)	T (Sig.)	T (Sig.)	T (Sig.)	T (Sig.)
Curved 1 - Curved 2	-25.24 (0.00)	11.62 (0.00)	-1.12 (0.27)	-5.34 (0.00)	-12.43 (0.00)	2.97 (0.01)	4.64 (0.00)	1.20 (0.24)	.62 (0.54)
Curved 1 – Curved 3	-19.59 (0.00)	24.67 (0.00)	-.67 (0.51)	-7.14 (0.00)	-4.53 (0.00)	.28 (0.78)	1.46 (0.15)	-.12 (0.91)	-3.07 (0.00)
Curved 1 - Curved 4	-14.94 (0.00)	35.84 (0.00)	1.20 (0.25)	-5.21 (0.00)	-23.14 (0.00)	-.60 (0.55)	-2.62 (0.01)	-1.49 (0.15)	-1.47 (0.16)
Curved 1 - Curved 5	-16.36 (0.00)	13.54 (0.00)	1.09 (0.28)	-3.09 (0.00)	-17.49 (0.00)	-7.33 (0.00)	-7.42 (0.00)	-7.66 (0.00)	-2.98 (0.01)
Curved 2 - Curved 3	-7.52 (0.00)	15.42 (0.00)	-3.22 (0.00)	-3.02 (0.00)	8.25 (0.00)	-2.14 (0.04)	-2.34 (0.02)	-1.99 (0.05)	-1.03 (0.31)
Curved 2 - Curved 4	-9.74 (0.00)	22.91 (0.00)	7.09 (0.00)	-2.14 (0.04)	-1.38 (0.18)	-3.93 (0.00)	-6.14 (0.00)	-4.79 (0.00)	-4.66 (0.00)
Curved 2 - Curved 5	-6.19 (0.00)	9.00 (0.00)	-2.66 (0.01)	3.55 (0.00)	3.89 (0.00)	-8.36 (0.00)	-14.08 (0.00)	-9.59 (0.00)	-3.48 (0.00)
Curved 3 - Curved 4	.14 (0.89)	5.13 (0.00)	1.32 (0.19)	2.32 (0.04)	-4.72 (0.00)	-.89 (0.38)	-4.20 (0.00)	-2.67 (0.01)	-.45 (0.66)
Curved 3 - Curved 5	7.97 (0.00)	-8.84 (0.00)	2.05 (0.04)	5.38 (0.00)	-7.25 (0.00)	-6.25 (0.00)	-13.22 (0.00)	-7.16 (0.00)	-1.51 (0.14)
Curved 4 - Curved 5	13.19 (0.00)	-41.32 (0.00)	-5.12 (0.00)	3.43 (0.00)	5.07 (0.00)	-4.43 (0.00)	-6.23 (0.00)	-4.18 (0.00)	.18 (0.86)

Note: The values of t and sig values in the T tests were in the 95% confidence interval.

Table2. T tests between each session of the curved road driver performance and vehicle performance

Shijiazhuang Tiedao University
Kang Xuejian
2019-08-07

• 5 Data Analysis

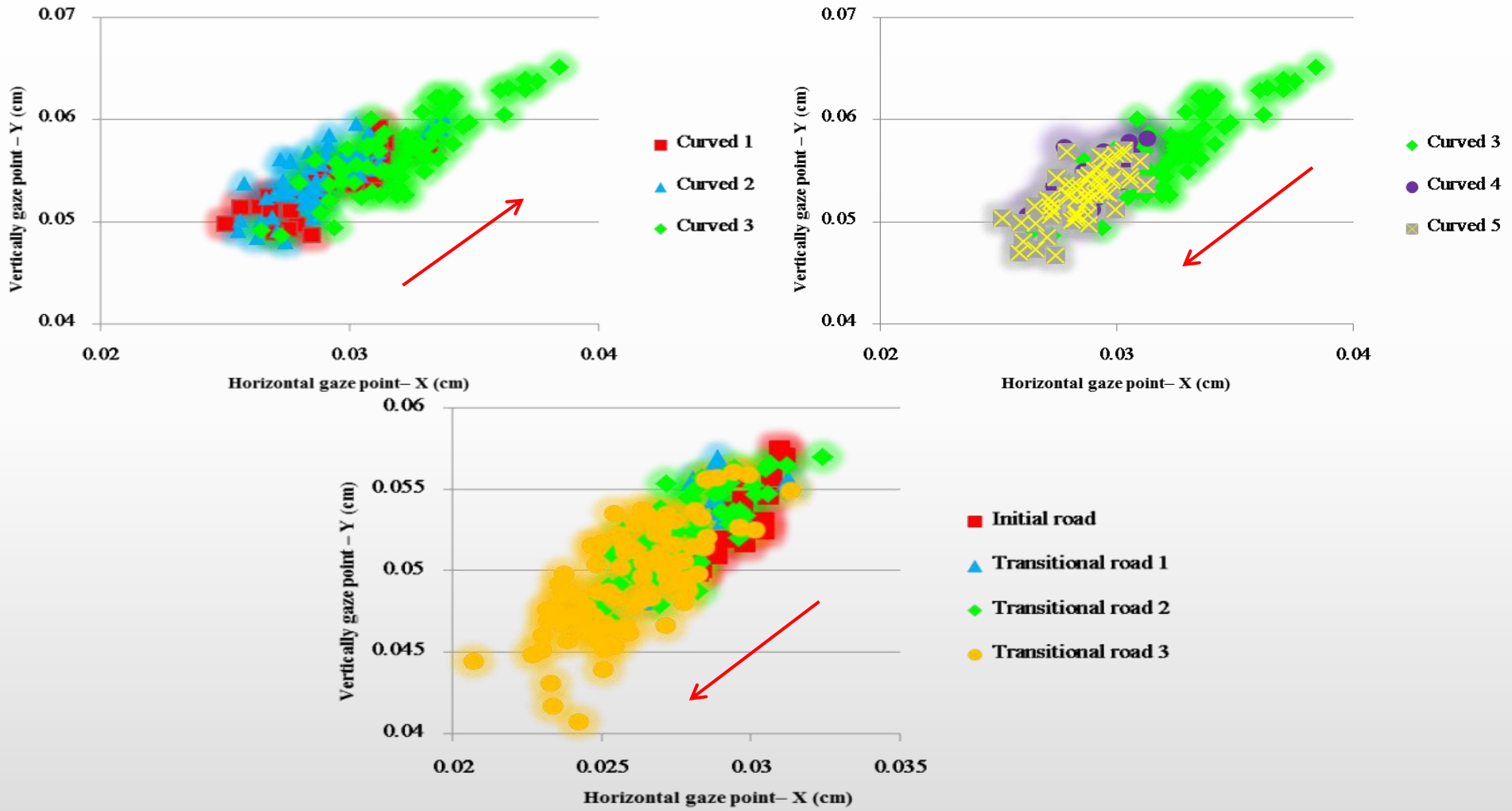
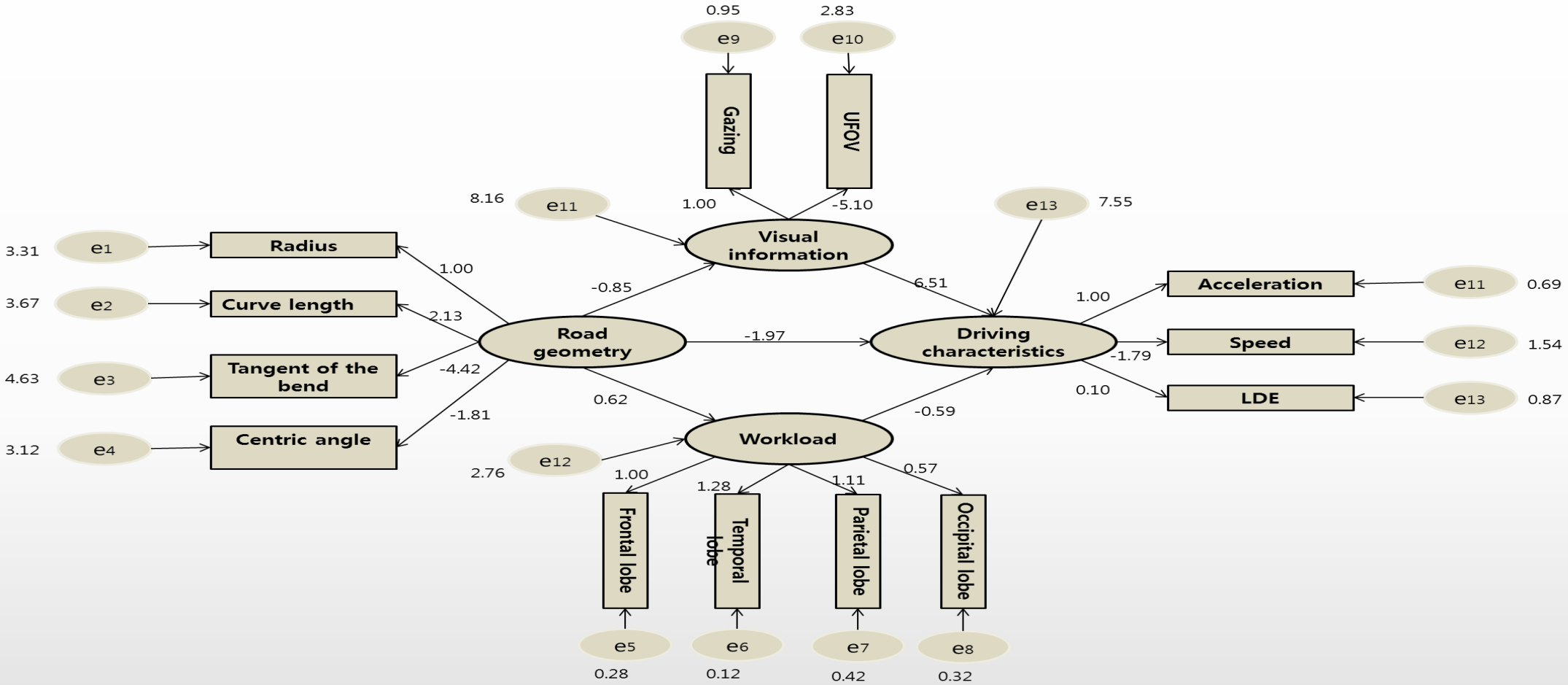


Fig.3 Gazing point direction for the different road condition during the driving activity.

Shijiazhuang Tiedao University
Kang Xuejian
2019-08-07

• 5 Data Analysis



Index	χ^2	df	χ^2/df	RMSEA	GFI	PNFI	PGFI	IFI	CFI	NFI	AGFI
Estimate results	554.70	260	2.13	0.07	0.91	0.54	0.58	0.90	0.91	0.78	0.88
Criteria Value			5	0.1	0.9	0.5	0.5	0.9	0.9	1	0.9

Fig.4 Variables and model estimation results

Shijiazhuang Tiedao University
Kang Xuejian
2019-08-07

• 6 Results and Discussion

• The **purpose** of the present study which investigated a simulator-based method was to test whether continuous curved road sub-groups differing in driving behavior and vehicle maneuver, and how curved road and transitional road conditions to influence the drivers' driving characteristics and behavior. As the descriptive statistics showed, the curves section were influenced by the human factors and the driving behavior, especially the continuous curves' (curve 1 to curve 3) radius had significant effect on the lane position error.

.

• **Firstly**, driving fundamentally require the ability to control vehicle maneuver to negotiate curves at high-speeds whilst taking appropriate trajectories along curved roadways. In the process of driving on the highway, the geometric factors of the road (curves and transitional road) have a significant impact on the driver's driving expectations, driving behavior and vehicle maneuver.

• **Secondly**, speed, acceleration, lane position error are effective means by which the driver manipulates the vehicle to keep the vehicle safe.

• **Thirdly**, the visual behavior of the UFOV transferred to the driving attention. Gaze weighing is also significant impact.

• **Fourthly**, workload increased with the driving distance implementation of the increase. Workload in curves is always higher than that under the transitional road condition. But workload only had an effect on the speeds used on the curves and no effect within straights.

• 6 Results and Discussion

Limitation

• **Firstly**, the study designed a fixed traffic flow, and vehicles traveling on a fixed vehicle line as the baseline conditions.
• **Secondly**, the conditions of road operation are single, and the complexity of traffic environment is not fully considered.
• **Thirdly**, experimental road distance is relatively short, there is no sufficient data to do the comparison and regression.
• **Fourthly**, driving simulators are known to be able to provide metrics that are predictive of real-world driving.

Further research

• Further research will focus on investigating the different curved road data under the real-word environmental conditions to validate its reproducibility and authenticity.
• The driving attention during other tasks relevant to human behavior, like heart and mental system, will be examined.
• With respect to physiology-based measures, it is essential to evaluate all relevant personal characteristics aspects to ensure the universality and rationality of analysis.

石家莊鐵道大學
Shijiazhuang Tiedao University

THANK YOU!

Analysis of vehicle maneuverability and driver characteristics on a curved road

Kang Xuejian

Shijiazhuang Tiedao University

School of Traffic and Transportation Engineering

2019-08-07