Project No. 2306B

<Government/Organization Cooperation>>>

Research on Efficient Accident Prevention Measures Using Artificial Intelligence

Project Leader: Akinori Morimoto, Waseda University

1．Research Summary

1.1 Project Members

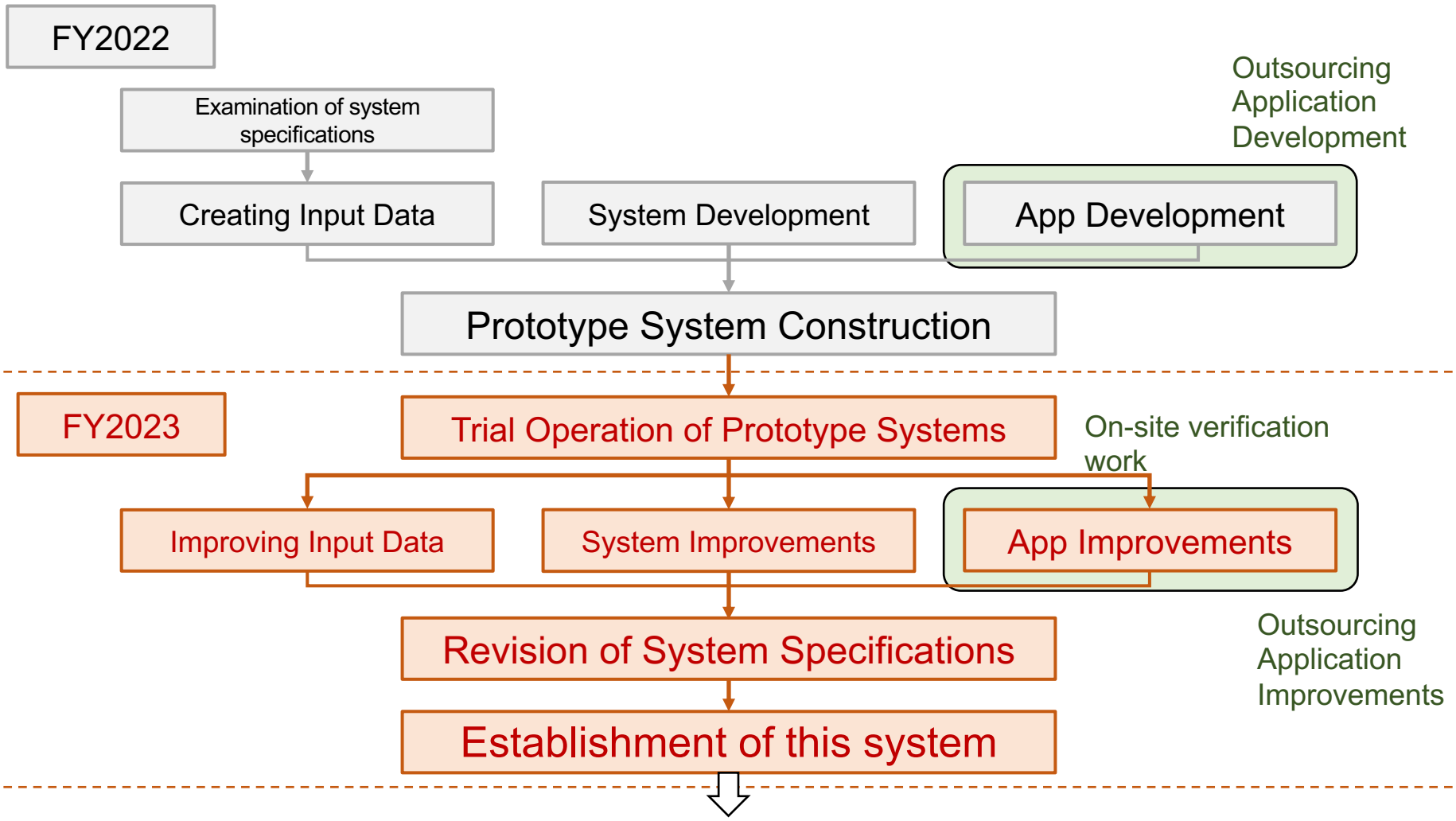
PL	Akinori Morimoto	Professor, Faculty of Science and Engineering, Waseda University
Member	Kazusei Kato	Professor, Faculty of Business and Commerce, Keio University
	Rumiko Iwasada	Automobile Journalist
	Akihiro Nakamura	Professor, Faculty of Economics, Chuo University
	Hidekatsu Hamaoka	Professor, Graduate School of Engineering Science, Akita University
	Yuka Nakagawa	Professor, Faculty of Law, Chukyo University / Attorney at Law, Nakagawa Law & Consulting
	Nobuaki Takubo	Deputy Director, Research Department, Institute for Traffic Accident Research and Data Analysis
Postdoctoral Researcher	Daisuke Kamiya	Associate Professor, Department of Engineering, Faculty of Engineering, University of the Ryukyus
	Kyoko Manaka	Associate Professor, Faculty of Economics, Ryutsu Keizai University
	Osamu Furukawa	Advisor, International Association of Traffic and Safety Sciences Senior Assistant to the President, Professional University of Electric Mobility Systems
	Keidai Kurashina	Waseda University Graduate School, Master's degree 2nd year
	Yasushi Nishida	
Research Collaborators	Toyoki Kurihara	Waseda University, 4th year undergraduate

Observer : National Police Agency, Metropolitan Police Department, Ministry of Land, Infrastructure, Transport and Tourism, CTI Engineering Co., Ltd., NEC Corporation, Informatix Inc.

- The 11th Traffic Safety Basic Plan "promotion of traffic guidance and control that contributes to the deterrence of traffic accidents" as a priority measure.
- Digital Agency was established in 2021. Standardization and other measures are needed in the field of traffic safety.
- IATSS has published a Traffic Enforcement Handbook since 2014 to provide ongoing information to those involved in traffic enforcement.

Developed a fundamental model that will lead to progress in accident deterrence countermeasures, utilizing AI, which is rapidly becoming more widely used.

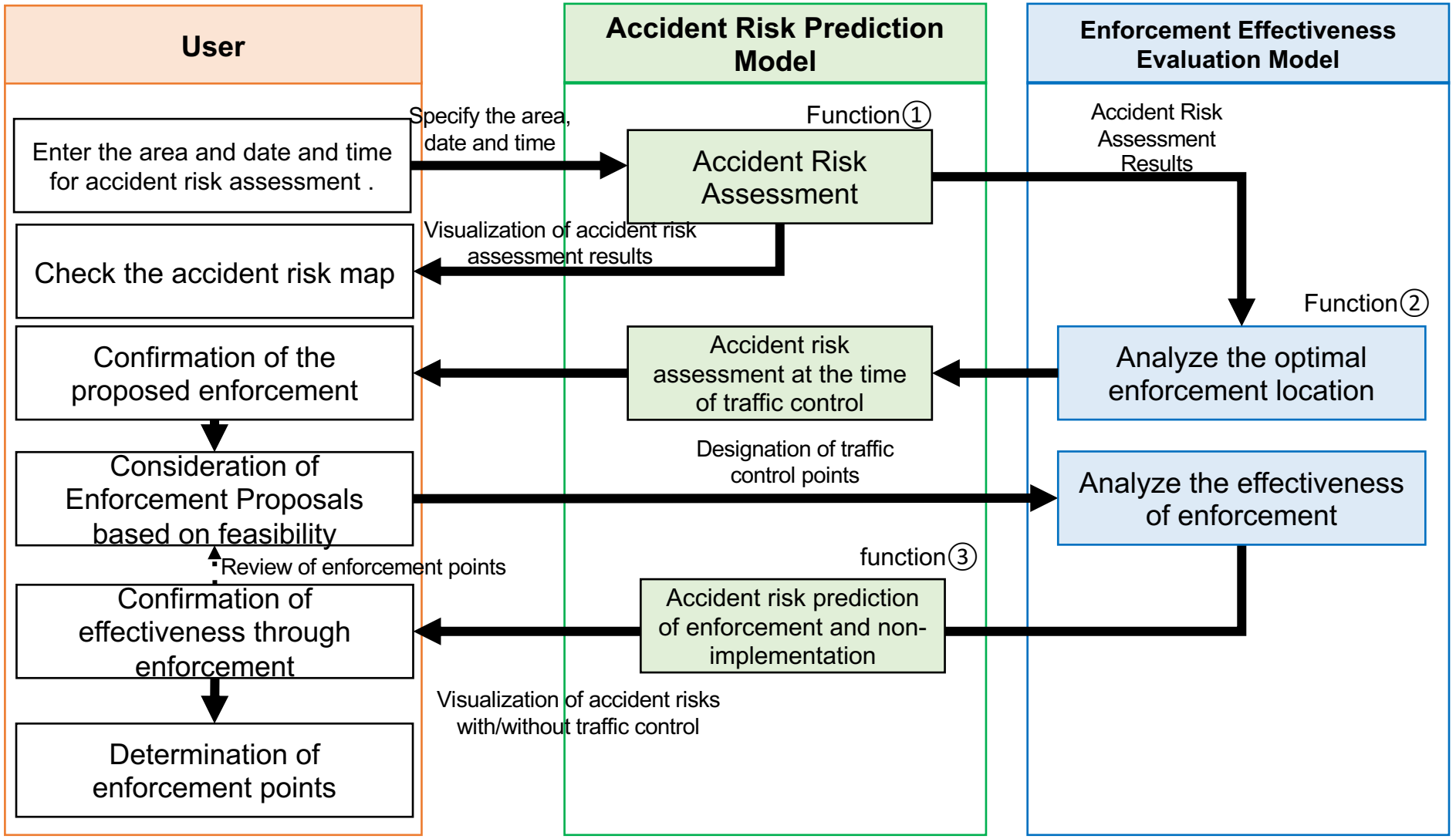
Development of general-purpose applications to enable deployment in diverse regions and accumulation of countermeasure effects to study community-based countermeasure proposals


FY2022
Examination of system specifications
Creating Input Data
System Development
App Development
Outsourcing Application Development
Prototype System Construction
FY2023
Trial Operation of Prototype Systems
On-site verification work
Improving Input Data
System Improvements
App Improvements
Revision of System Specifications
Establishment of this system
Outsourcing Application Improvements
Final year（FY2024）
Expansion to other regions and revision of the handbook

2．Overview of the Traffic Guidance and Control Activity Support System

2.1 Overview of the Traffic Guidance and Control Activity Support System

- Support the determination of control points by combining the "Accident Risk Prediction Model" and the "Control Effectiveness Evaluation Model" and visualizing the model calculation results in a series.



- STEP① : Select the jurisdictional area where traffic control activities will be conducted

①Select the target jurisdiction area

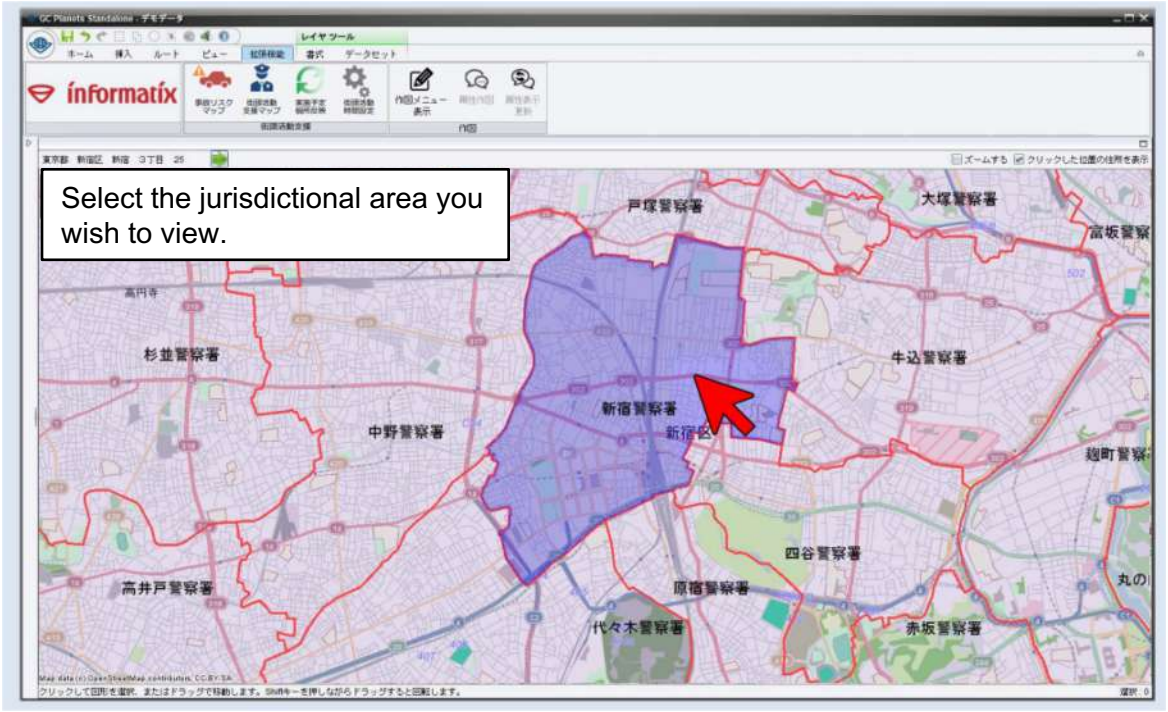
②Refer to the current accident risk

③Set mandatory activity locations

④Enter the weather for the date

⑤Simulation

⑥Confirmation of prediction results



- STEP② : View the current accident risk in the selected jurisdiction

①Select the target jurisdiction area

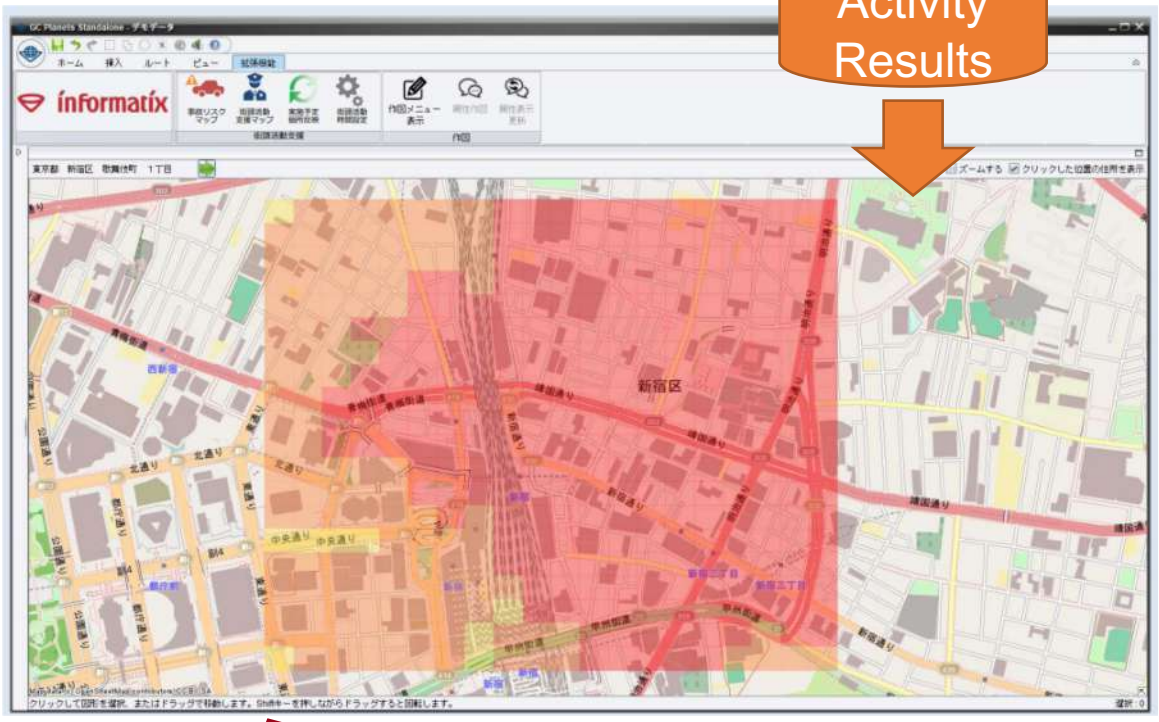
②Refer to the current accident risk

③Set mandatory activity locations

④Enter the weather for the date

⑤simulation

⑥Confirmation of prediction results



- STEP③：Select locations if traffic control locations are pre-determined

①Select the target jurisdiction area

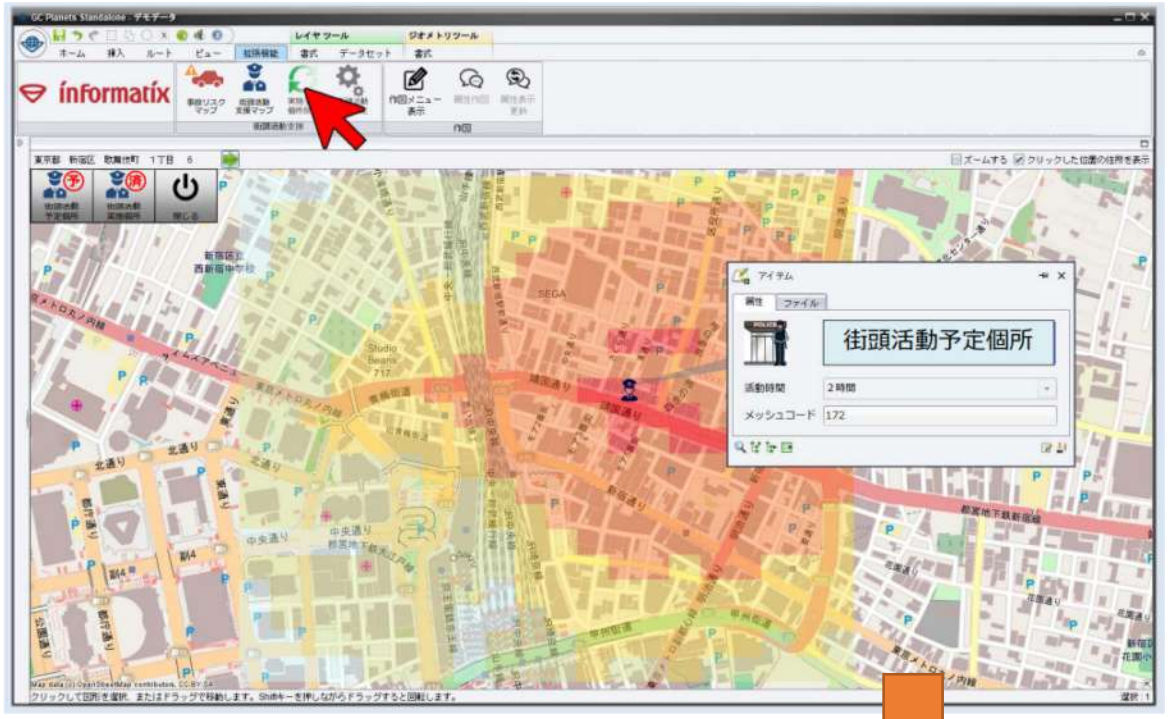
②Refer to the current accident risk

③Set mandatory activity locations

④Enter the weather for the date

⑤Simulation

⑥Confirmation of prediction results



Forecast conditions

- STEP④：Enter the weather conditions on the day of the enforcement activity with reference to the weather forecast, etc.

①Select the target jurisdiction area

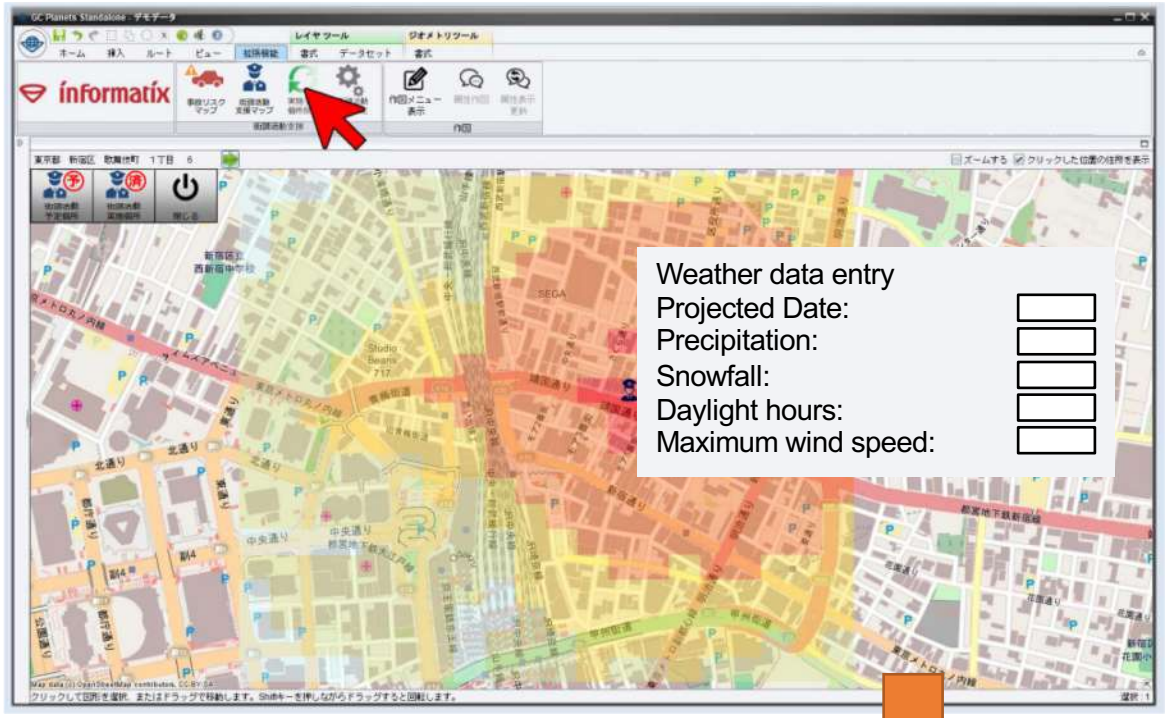
②Refer to the current accident risk

③Set mandatory activity locations

④Enter the weather for the forecast date

⑤Simulation

⑥Confirmation of prediction results



Traffic Amount Prediction Data

- STEP⑤： Calculate the effect of conducting control activities within the jurisdictional area

①Select the target jurisdiction area

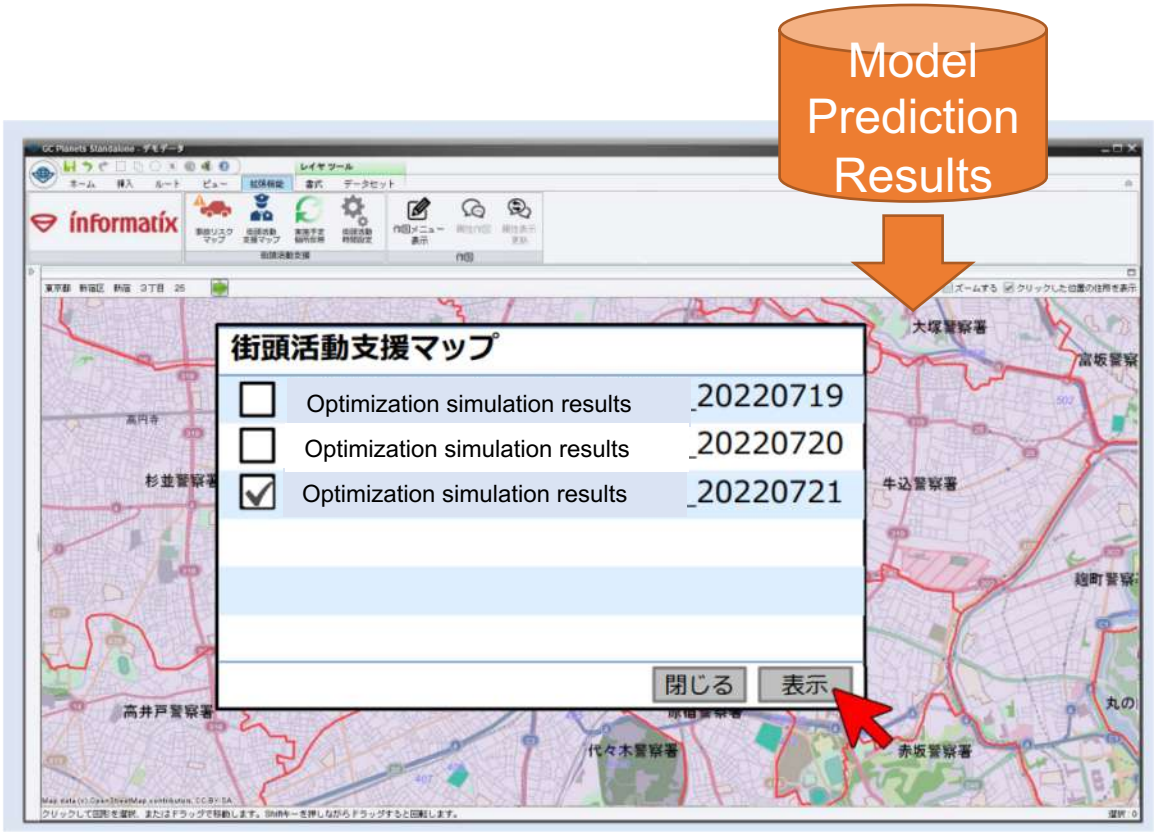
②Refer to the current accident risk

③Set mandatory activity locations

④Enter the weather for the date

⑤Simulation

⑥Confirmation of prediction results



- STEP⑥: When the location of the enforcement activity is specified, the effectiveness of the enforcement in that case is displayed

①Select the target jurisdiction area

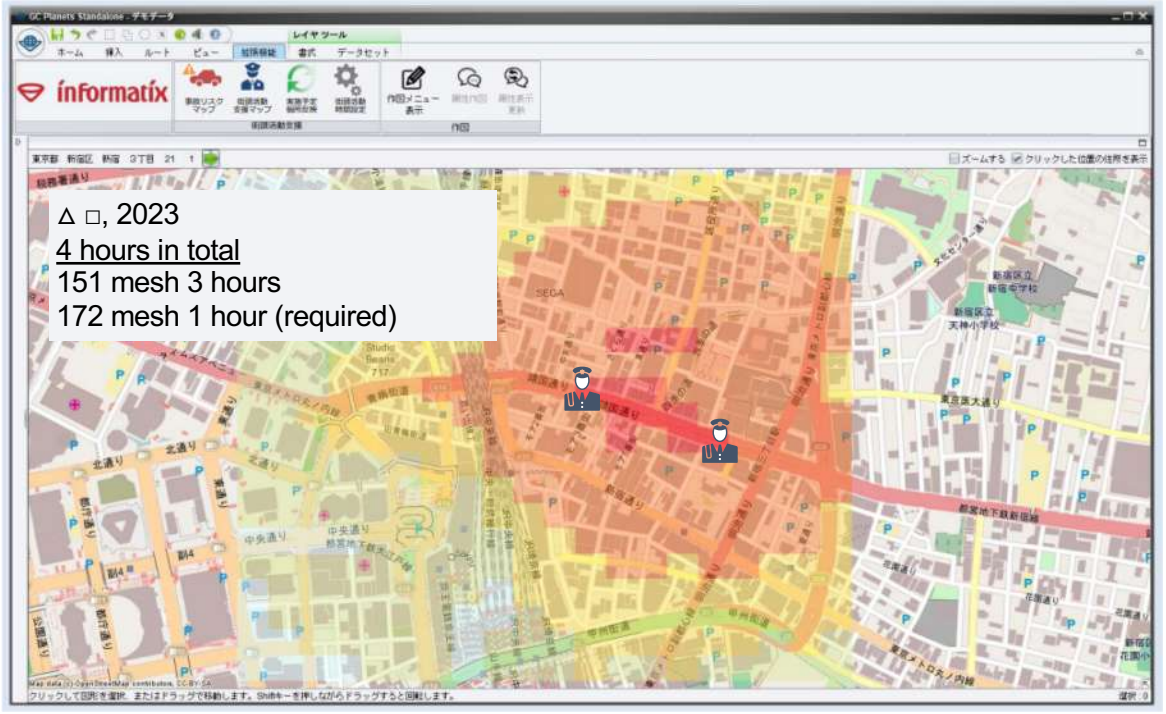
②Refer to the current accident risk

③Set mandatory activity locations

④Enter the weather for the date

⑤Simulation

⑥Confirmation of prediction results



- The prototype support system was verified in actual road traffic, and issues related to the convenience and adaptability of the system to practical work were identified.
- The 2022 model has been improved and the basic model and system have been improved.

3．Improvement of the Basic Model

2022 Traffic Guidance and Enforcement Support Model

①Accident Risk Prediction Model

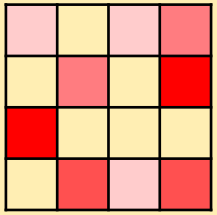
Method：Multiple Regression Bayes

Predict accident risk **in units of 50 meters per day**

Objective Variables	Accident risk value
Explanatory variables	Enforcement activity value[h]
	Number of intersections
	Top speed[km]
	Traffic amount

Output data

Accident Risk Prediction

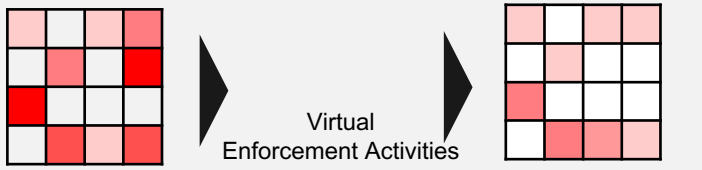


Mesh	Predicted value
No.1	0.2
…	…
No.16	0.7

②Enforcement Activity Proposal Model

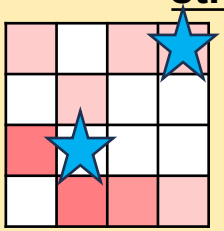
Method：Deep Q-Network

Proposing enforcement activities to **maximize the amount of reduction** in accident risk value



Output data

Optimal location and time for street activities



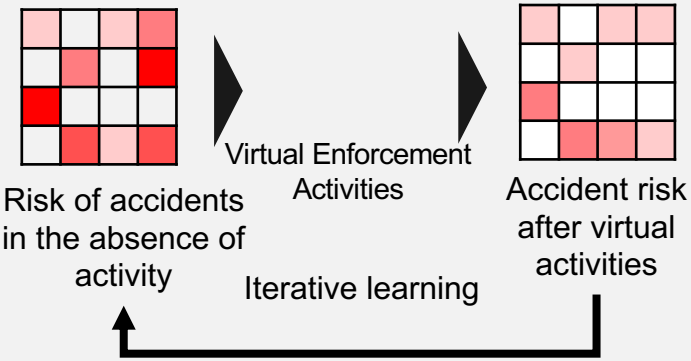
mesh	Event time[h]
No.4	2
No.10	1

- Improvements were made to the model for proposed enforcement activities. Refinements were made to the model.

②Enforcement Activity Proposal Model

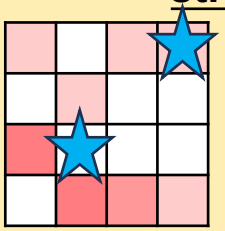
Method：Deep Q-Network

Proposing enforcement activities to **maximize the amount of reduction** in accident risk value



Output data

Optimal location and time for street activities



Mesh	Event time[h]
No.4	2
No.10	1

Focus for improvement

- Concentration of calculation results in one place when calculating activities for multiple hours
  →Discrepancy between the correct value and the calculated value of the model
- The model was difficult to converge

Implemented 3 points

- **Review of Reward**
  →In addition to the reduction of accident risk value reward based on traffic amount was added
- **Review hyper parameters**
  → Perform sensitivity analysis of parameters
- **Review of measures**
  → Change the rules for conducting the study.

(1) Review of Reward

- Points are exogenously added to traffic concentration points such as intersections between main roads and highways.

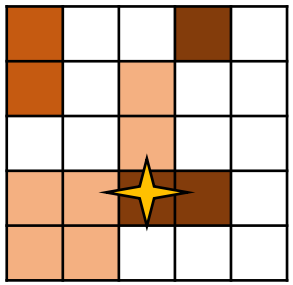
Location-specific reward

Main road	: +0.5
Intersections between arterial roads	: **+0.5**
Road occupancy 0%	: **-1.0**
Outside the jurisdiction of the target police station	: **-1.0**

So far

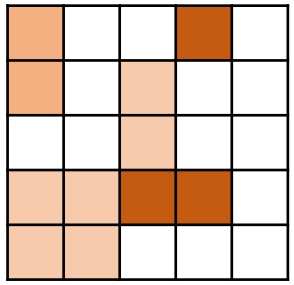
$$(reward) = risk0 - risk1$$

Before control



Accident risk value $(risk0)$

After control



Accident risk value $(risk1)$

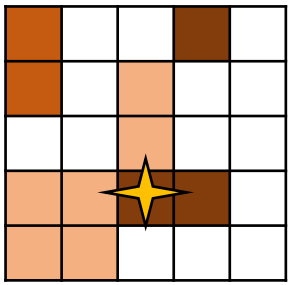
☆ : Control Activity Locations

After the change

$$(reward) = risk0 - risk1$$

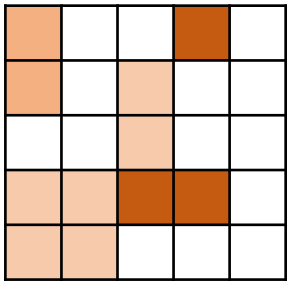
+Point-specific reward values

Before control



Accident risk value $(risk0)$

After control



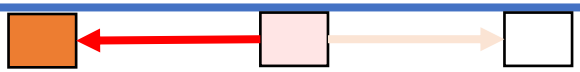
Accident risk value $(risk1)$

☆ : Control Activity Locations

Review of control activity values

■Distribution of the amount of accident risk reduction for the entire area during 1 hour of activity in each mesh

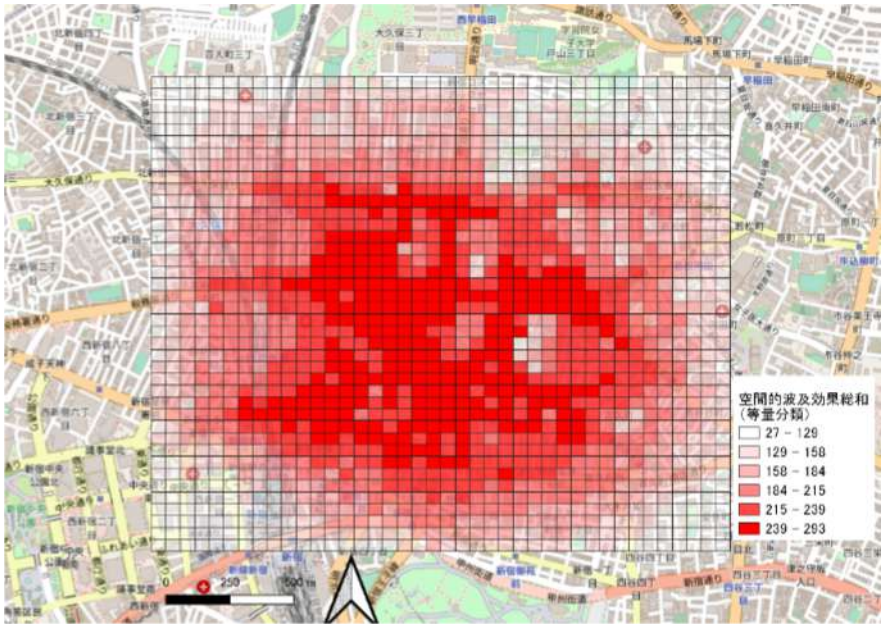
- Calculation of ripple effects that takes into account "arterial road connectivity" instead of "being located in the center of the target area" as in the past
- The effectiveness of the activity could be calculated based on the number of witnesses (traffic) to the activity.



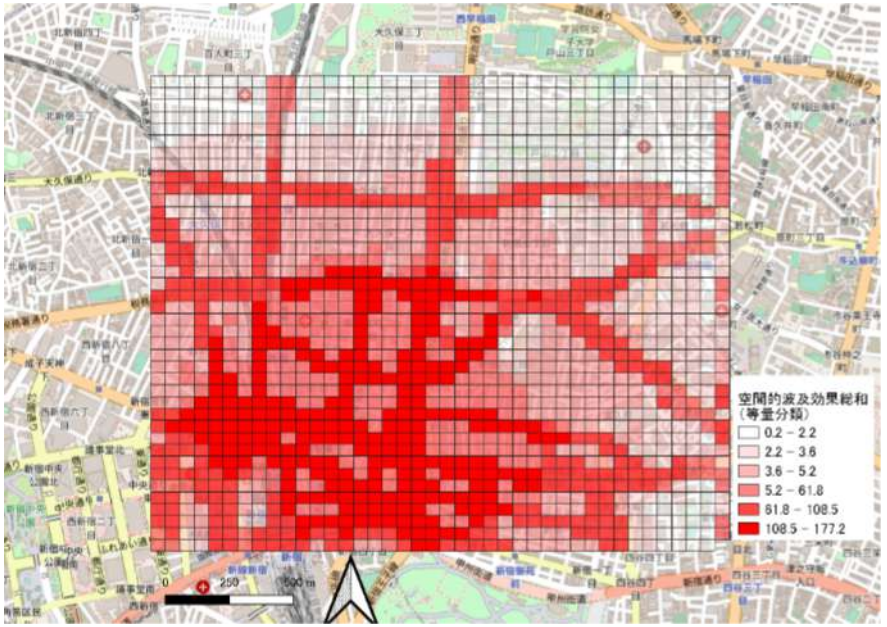
Highly effective in reducing accidents

Low accident reduction effect

Existing model



Review of ripple effects



(2) Review of hyperparameters

- Appropriate values are set by sensitivity analysis.

Experience Regeneration

Removing the correlation of experiences used when updating parameters and stabilizing learning

limit	Maximum number of training sessions to record
ignore_episode_boundaries	**Use the experience of another episode or not**

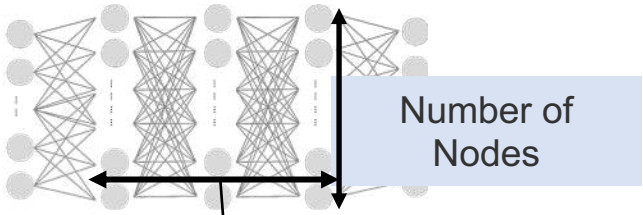
Agent (the main body that learns)

The subject performing the action

nb_steps_warmup	**Warm-up period without learning**
batch_size	Batch size
target_model_update	**How to update the target model**
enable_dueling_network	Conduct Dueling Network Insert or not

Neural network

Estimation of an approximation of the action value function (Q value)



Policy

Policy when choosing an action

ε	Random Action Choice Probability

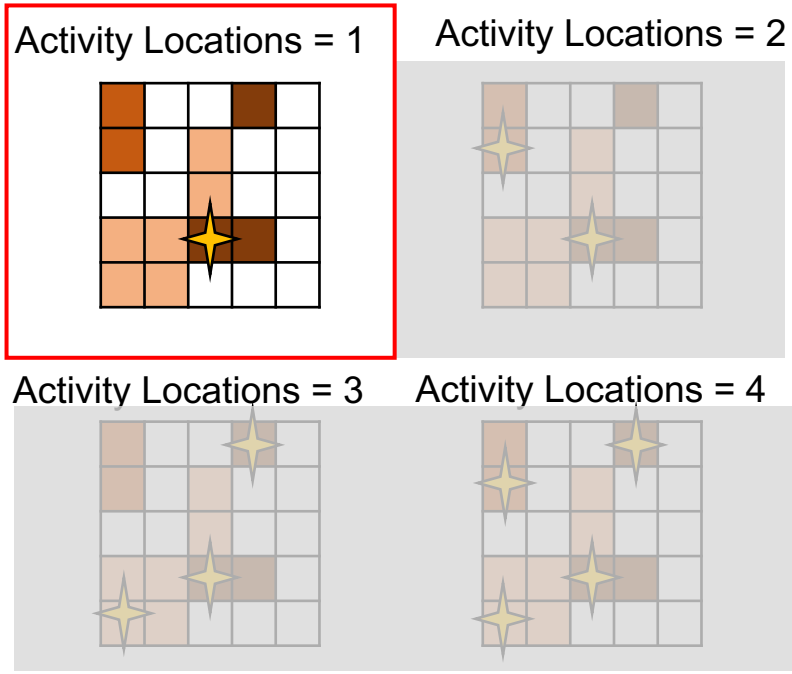
(3) Review of measures

- The learning rule is changed so that the calculation target is changed according to the number of activity locations desired by the user.

Users enter the number of **Event Time・Activity Locations**（Undecided is also possible）

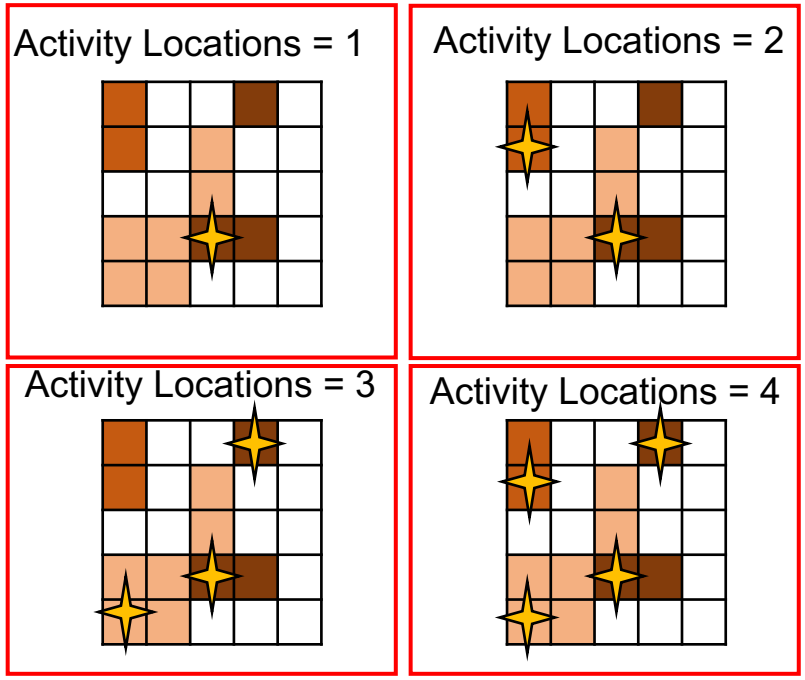
So far

Since the strategy is to select the mesh with the greatest effect, Activities of multiple hours at one location only are likely to be recommended



After the change

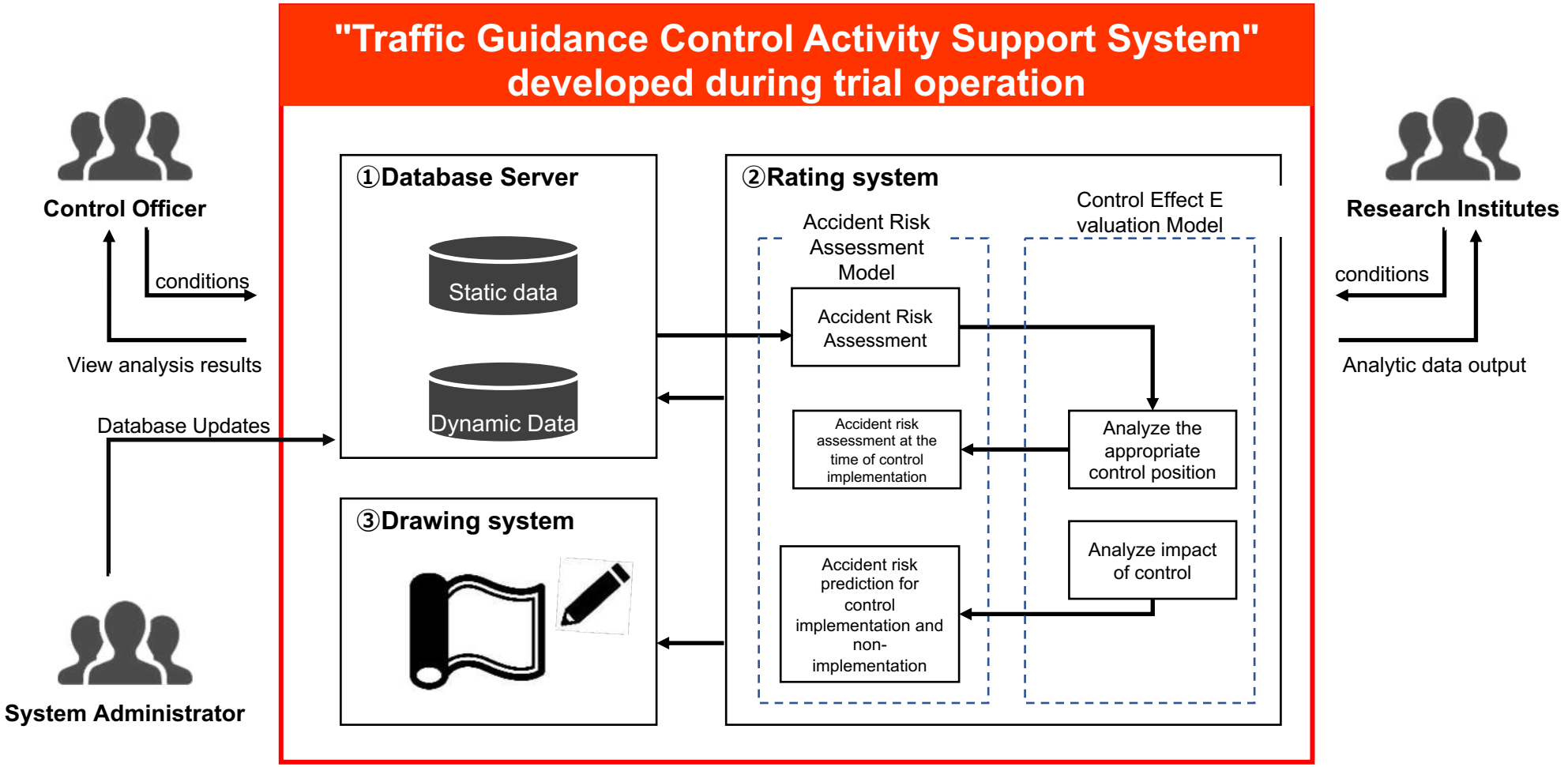
It is possible to change the number of activities to be recommended according to the number of activities entered by the user.



4. Trial operation of the traffic guidance control activity support system

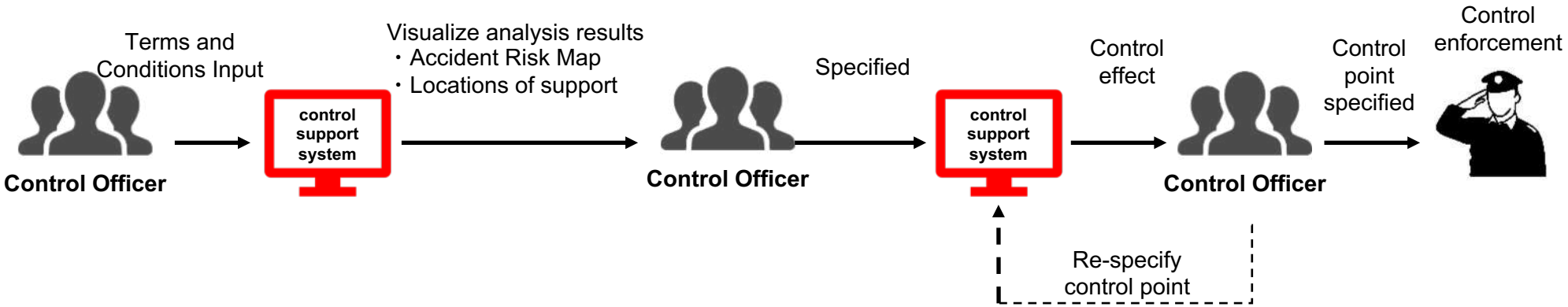
(1) System Overview

①System Overview Diagram

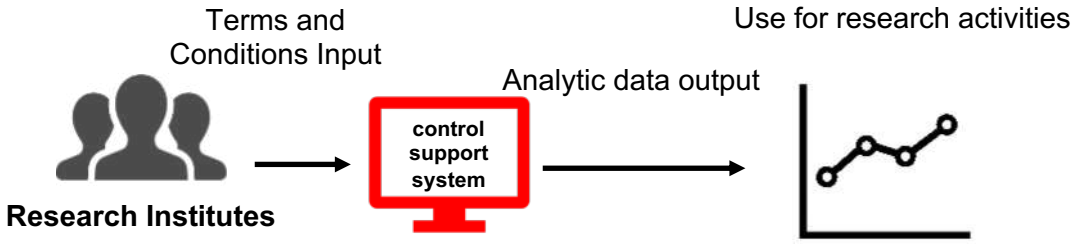


(1) System Overview

(2) Procedure for confirming the effectiveness of control implementation



②Analytic Data Extraction Procedure



4.1 Summary of the Trial Operation System

(1) Purpose of implementation

- A prototype system was built to develop a support system for traffic guidance and enforcement activities.
- With the cooperation of the Shinjuku Office, a prototype system will be operated on a trial basis to verify the effectiveness of the system implementation, as well as to improve the model and revise the system specifications.

(2) Location of implementation

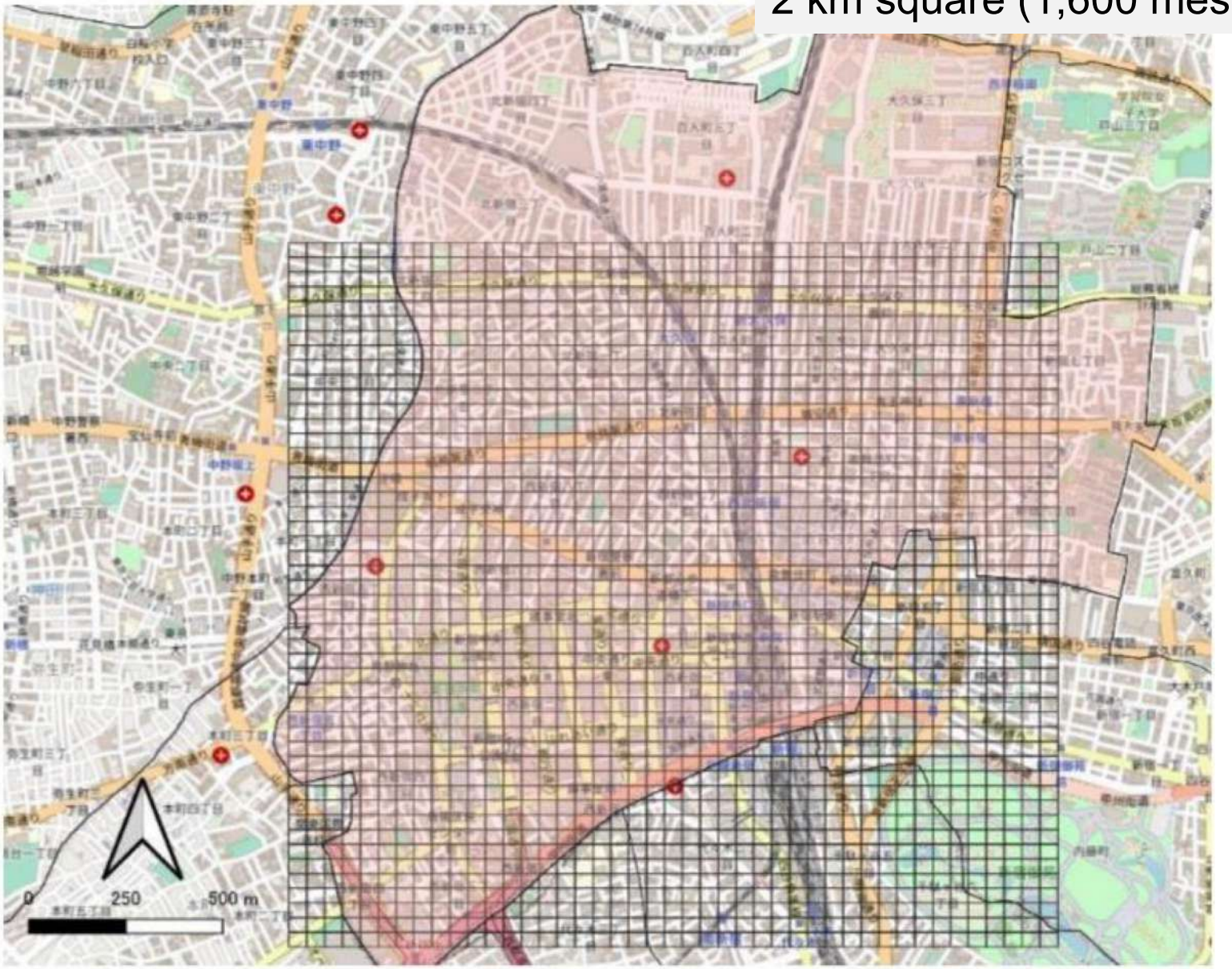
- Shinjuku Police Station
- See next page for areas subject to trial operation.

(3) Implementation period

- Monday, October 2, 2023 - Tuesday, October 31, 2023
- Equipment installation and operation training will be held on Friday, September 29, and trial operation will begin on Monday, October 2.
- Equipment was removed on Wednesday, November 1, and a hearing survey was conducted in conjunction with the equipment.

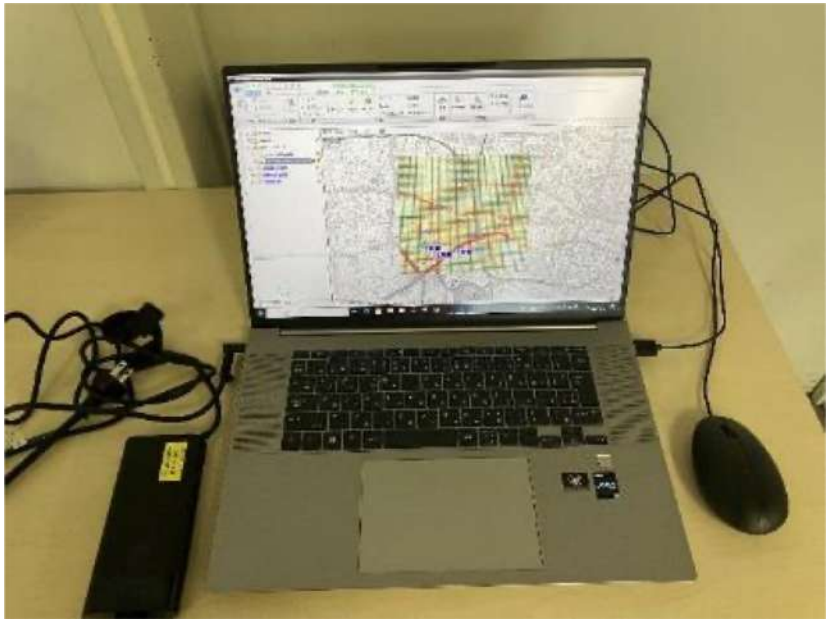
(4) Area subject to trial operation

2 km square (1,600 mesh)



(5) Equipment used

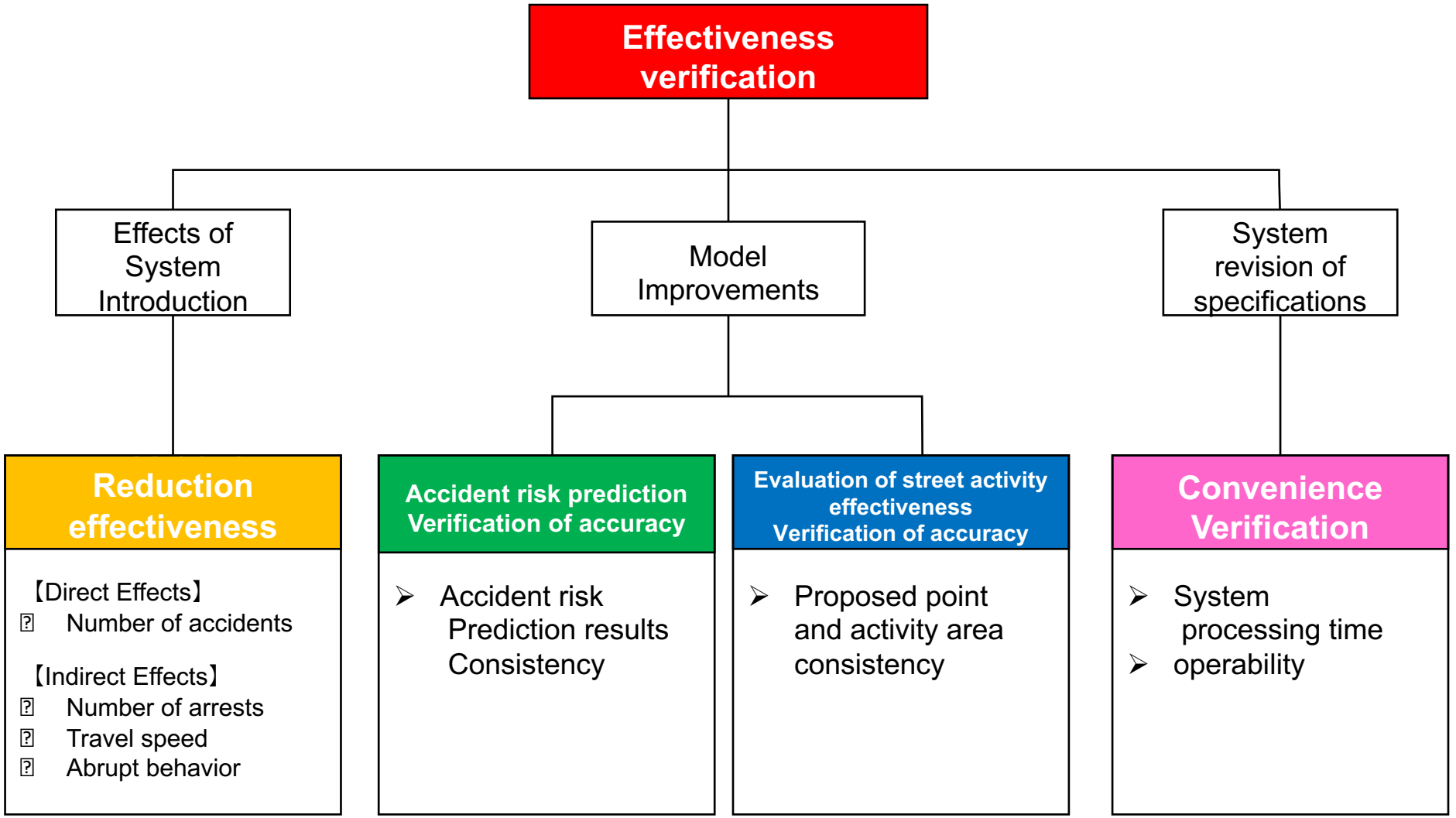
No	Equipment	Remarks
1	Terminal for operating the enforcement activity support system	1 laptop
2	Dedicated terminal for weather forecast checking	1 laptop (terminal owned by the Metropolitan Police Department)
3	Simplified Operation Manual	See Appendix



Installation image

Operation manual (Simplified Operation Manual)

4.3 Verification Items



(1) Accident Reduction Effectiveness Verification

(a) Number of accidents

The accident data currently available for 2023 are preliminary figures, and the number of accidents in 2023 is significantly smaller than that of 2022.
Below is an image of the analysis using the preliminary data.

Incidents during trial operation: **18**

2022 [Cases]

Month	1	2	3	4	5	6	7	8	9	10	11	12
People-to-vehicle	5	6	8	6	9	11	5	7	12	6	10	9
Vehicle-to-vehicle	19	13	20	16	16	17	31	31	19	23	32	26
Vehicle single	1	1	3	0	0	1	0	2	4	2	1	1
sum	25	20	31	22	25	29	36	40	35	31	43	36

2023 [Cases]

Month	1	2	3	4	5	6	7	8	9	10	11	12
People-to-vehicle	2	10	8	6	5	8	6	3	2	**6**	-	-
Vehicle-to-vehicle	15	13	21	14	11	13	13	11	16	**11**	-	-
Vehicle single	0	1	1	0	1	0	1	0	1	**1**	-	-
sum	17	24	30	20	17	21	20	14	19	**18**	-	-

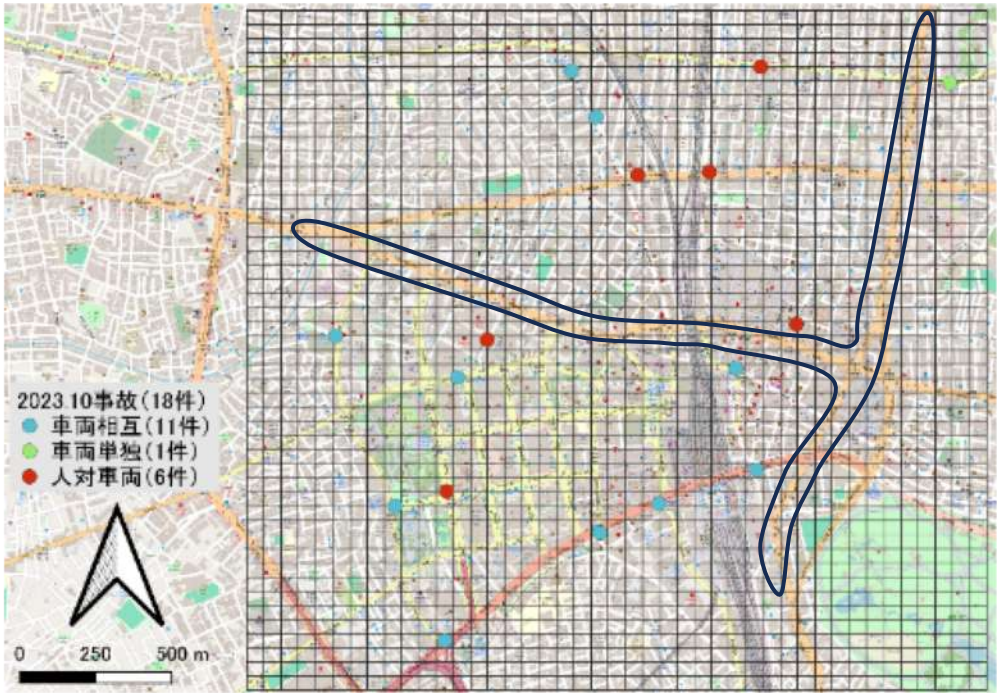
(1) Accident Reduction Effectiveness Verification

(a) Number of accidents

There is a strong possibility that accidents along Meiji-street and Ome-kaido are on an attenuating trend.

2022.10

2023.10



(1) Accident Reduction Effectiveness Verification

(b) Sudden behavior (ETC2.0 probe information)

Total number of cases multiplied by expansion factor for each month
2023 data is analyzed from the two months of September and October as preliminary data.

* All near-miss incidents in this document are calculated by multiplying the magnification factor.

Month	1	2	3	4	5	6
2022	1953,941	1926,462	1,110,166	1,043,251	1,048,242	1,062,208
2023	-	-	-	-	-	-

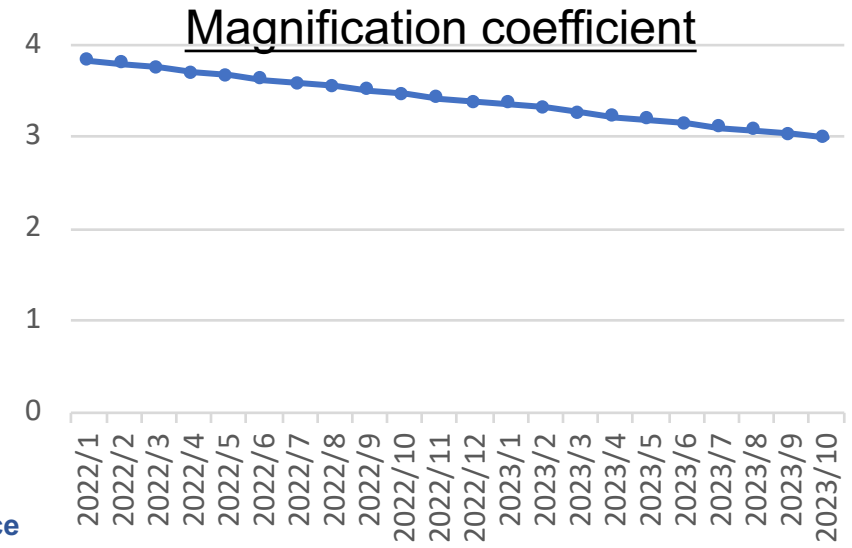
Month	7	8	9	10	11	12
2022	1,100,850	1,079,846	1,067,921	1,100,398	1,688,902	1,107,623
2023	-	-	1,039,290	1,072,688	-	-

ETC Probe Form 1-4

Total number of cases =

- Front and rear acceleration - 0.25G or less
- Successful Matching
- Number of data that satisfies the target 2064mesh

Number of data satisfying the above



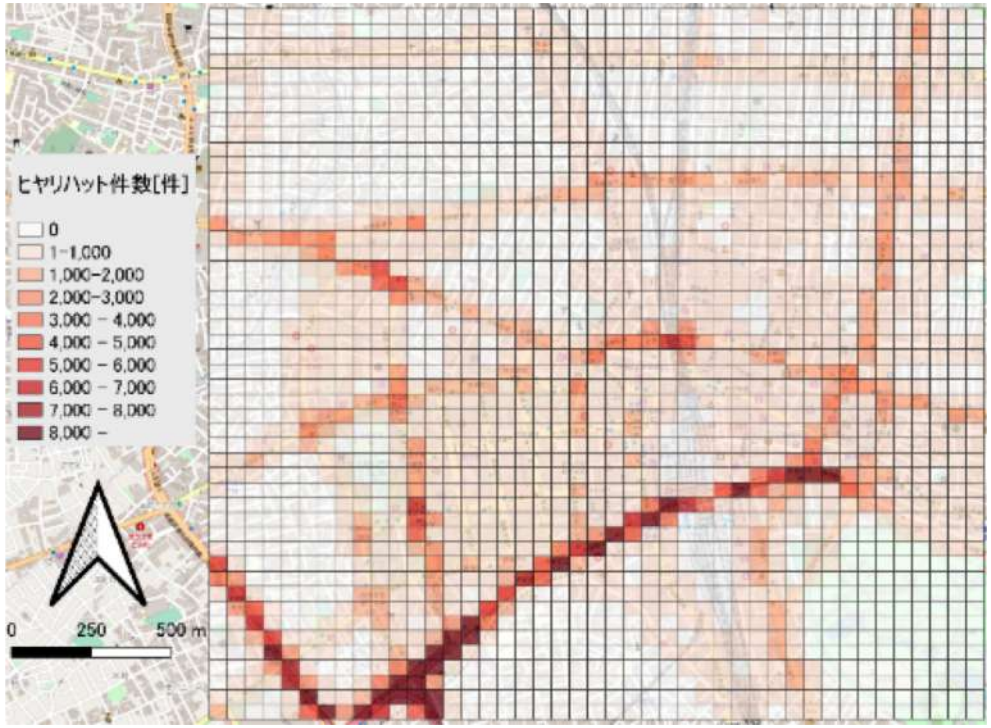
(1) Accident Reduction Effectiveness Verification

(b) Sudden behavior (ETC2.0 probe information)

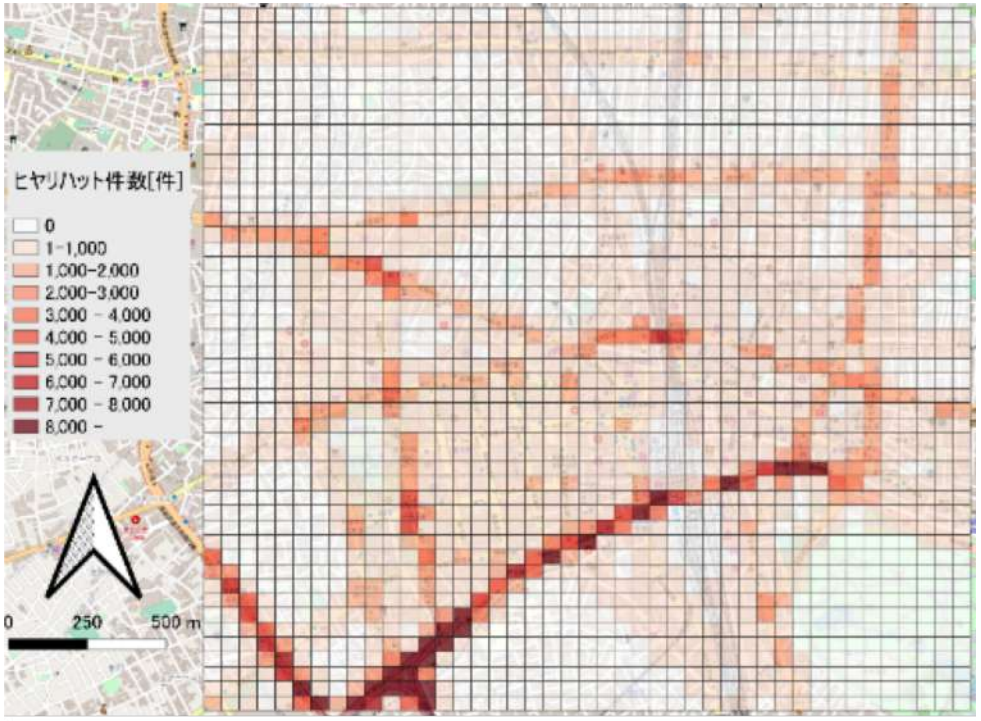
Comparison of the number of near-misses (2022.10 number of near-misses , 2023.10 number of near-misses)

There is no change in the tendency for incidents to occur on major arterial roads such as Koshu-kaido and Yamate-street.

2022.10



2023.10



(1) Accident Reduction Effectiveness Verification

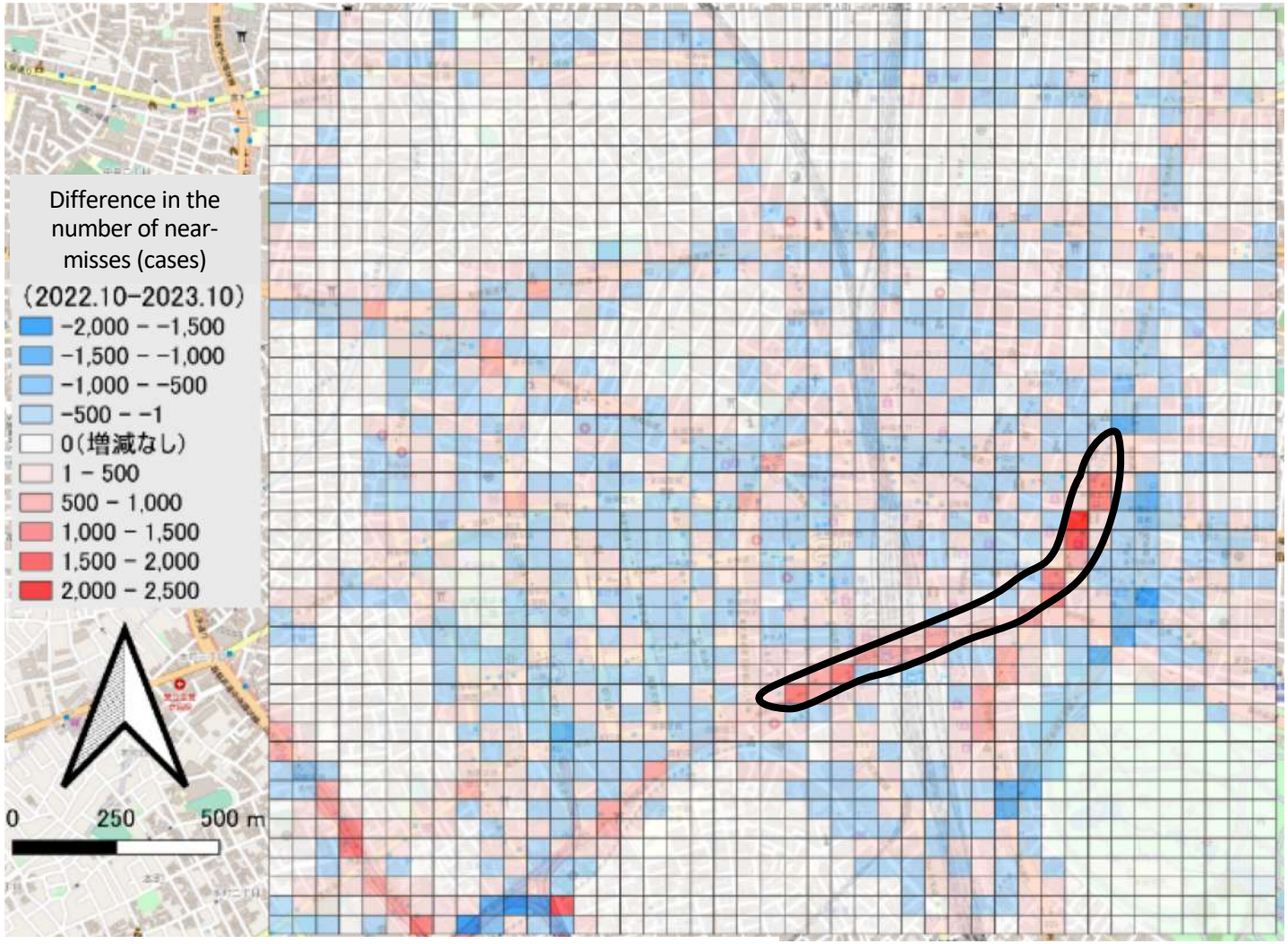
(b) Sudden behavior (ETC2.0 probe information)

Difference in the number of incidents (2022.10 near-misses - 2023.10 near-misses)

The number of near-misses on Meiji-dori and Koshu-kaido streets near Shinjuku Gyoen has been continuously decreasing.

Increase

Decrease



(1) Accident Reduction Effectiveness Verification

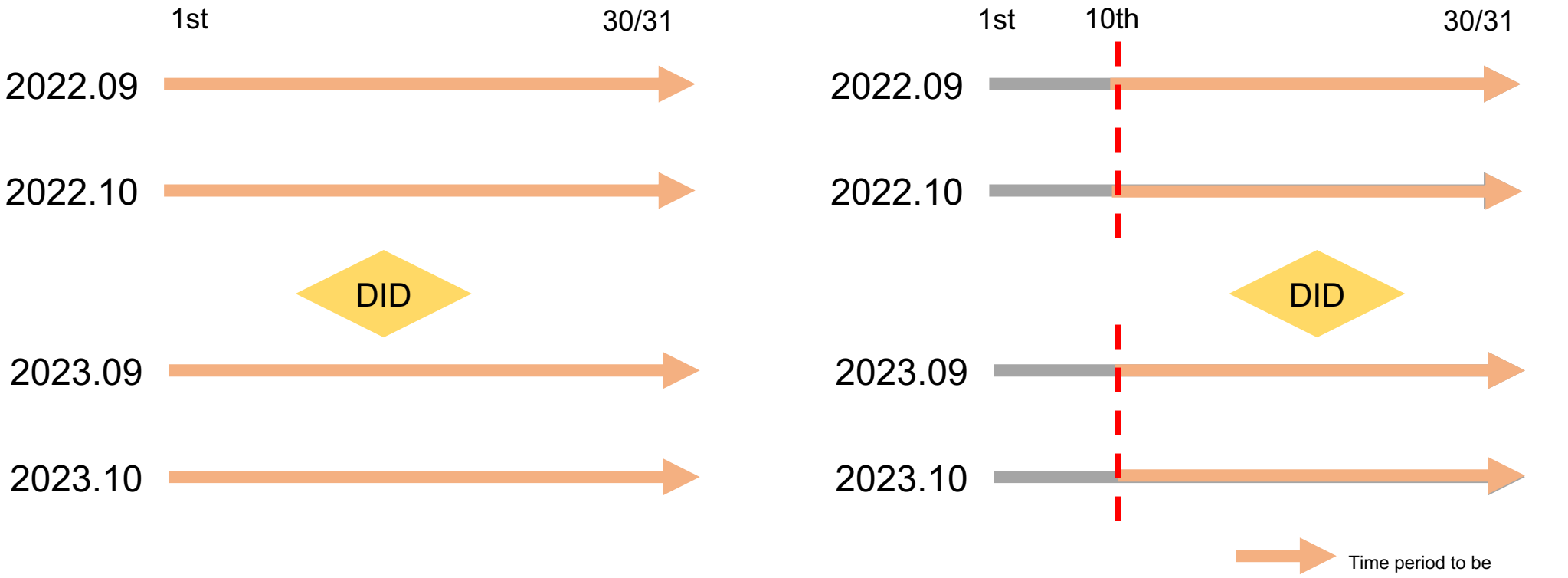
c) Differential analysis of differences in the number of traffic accidents and near-misses

Analysis Image

- The period covered was analyzed in two ways: on all days and after the 10th of each month.

For all days
→Data for all days of the period covered is used.

After 10 days
→The following is a list of the data for each month after the 10th day of the month.
Used data only



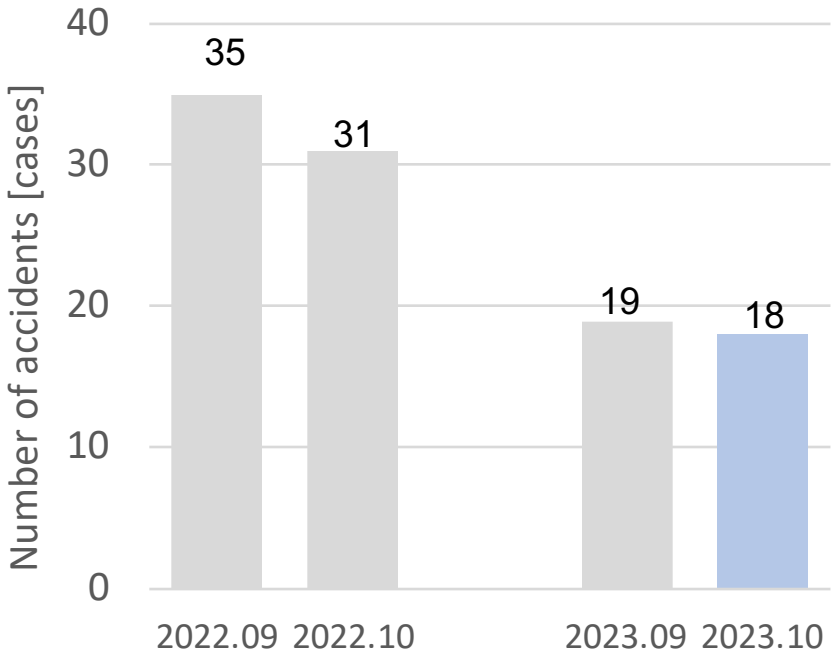
(1) Accident Reduction Effectiveness Verification

c) Differential analysis of differences in the number of traffic accidents and near-misses

Differential analysis of September and October differences for 2022 & 2023 (for all days)

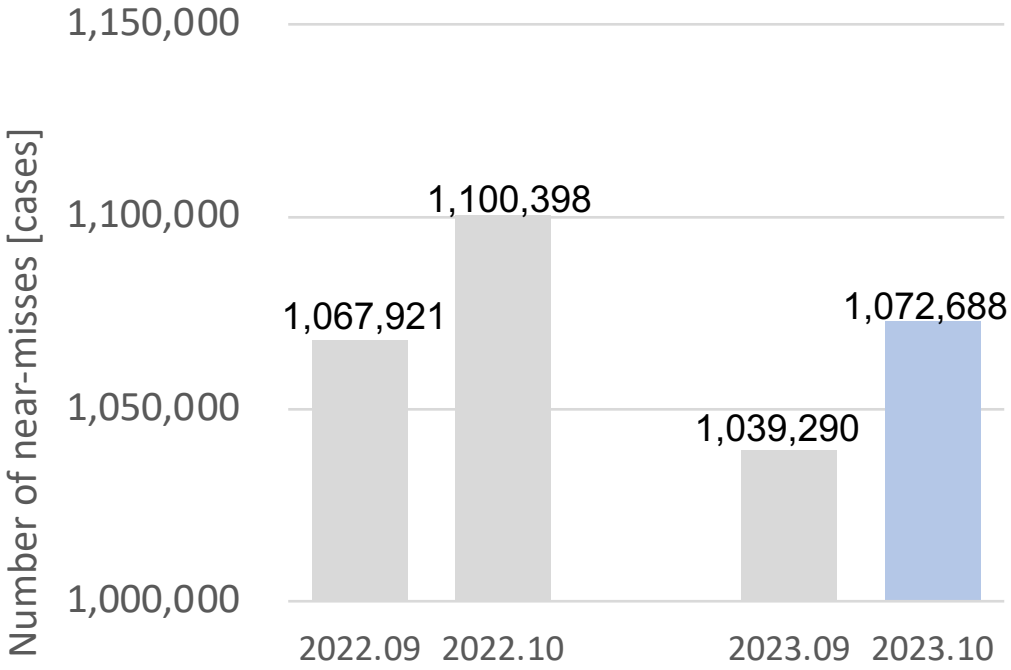
- The DID analysis for all days did not show a decrease in both the number of traffic accidents and near-misses.

Number of traffic accidents



[Cases]	September	October	Oct-Sep
2022	35	31	-4
2023	19	18	-1
		DID	+3 (increase)

Number of near-misses



[Cases]	September	October	Oct-Sep
2022	1,067,921	1,100,398	+32,477
2023	1,039,290	1,072,688	+33,398
		DID	+921 (increase)

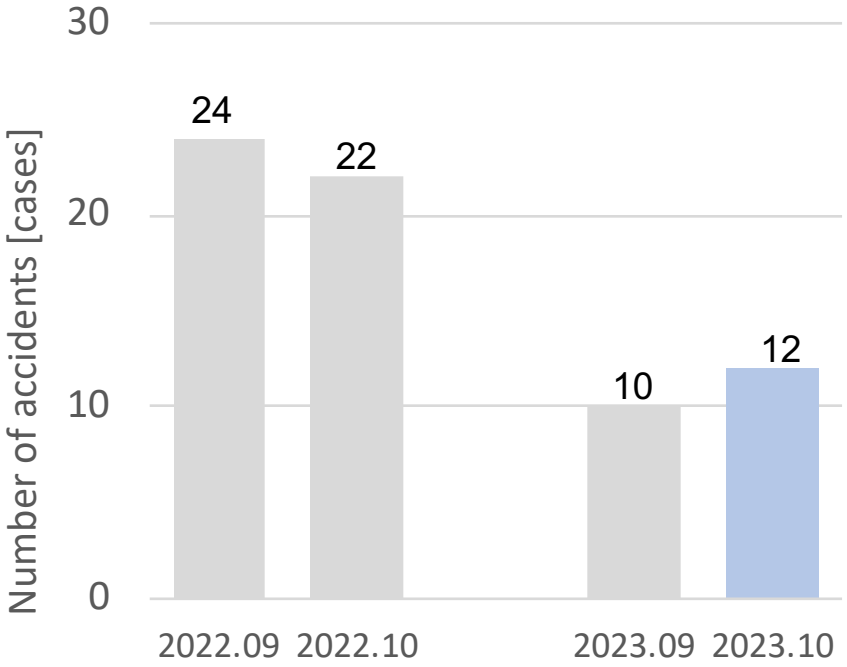
(1) Verification of accident reduction effects

c) Differential analysis of traffic accidents

Differential analysis for September and October 2022 & 2023（Applicable after the 10th of each month）

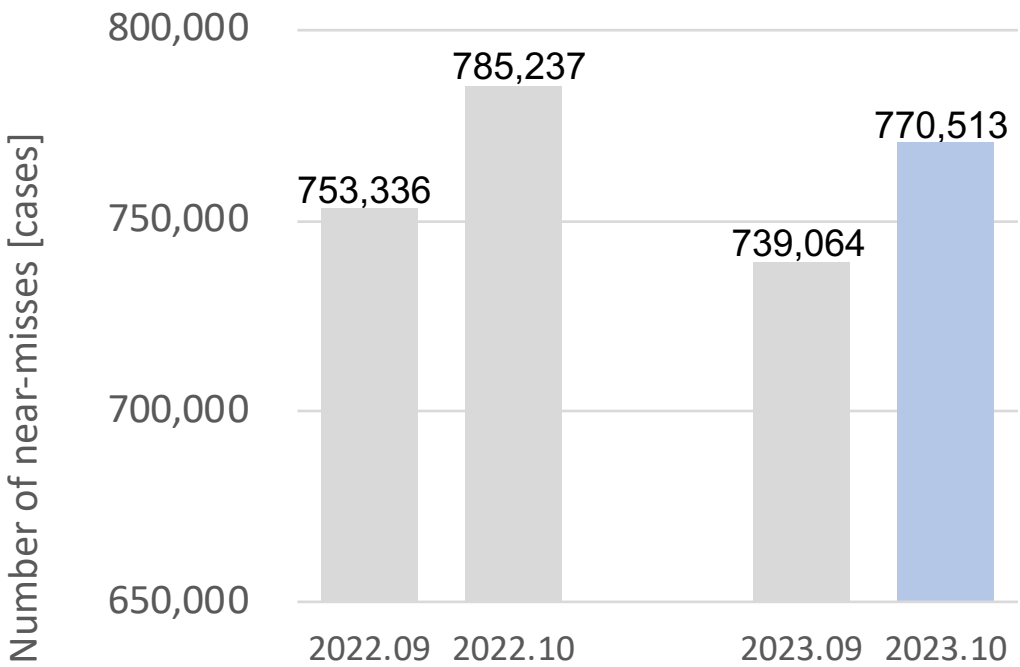
- In the DID analysis of the 10th day onwards, there was a downward trend in the number of near-miss incidents.

Number of traffic accidents



[Cases]	September	October	Oct-Sep
2022	24	22	-2
2023	10	12	+2
		DID	+4(Increase)

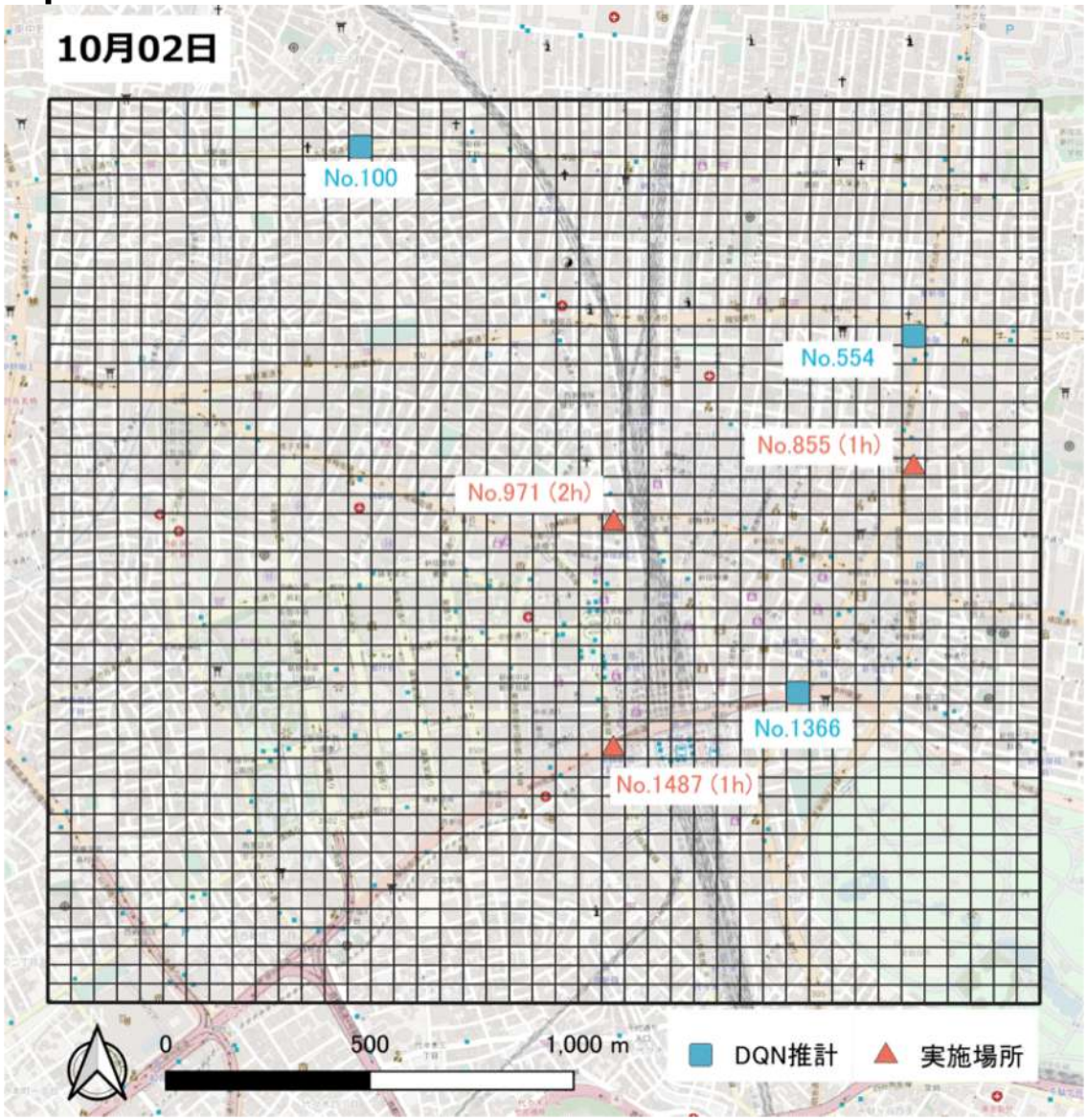
Number of near-miss incidents



[Cases]	September	October	Oct-Sep
2022	753,336	785,237	31,901
2023	739,064	770,513	31,449
		DID	452(Decrease)

(2) Accuracy verification of street activity effectiveness evaluation

(a) Street activity implementation records



(2) Accuracy verification of street activity effectiveness evaluation

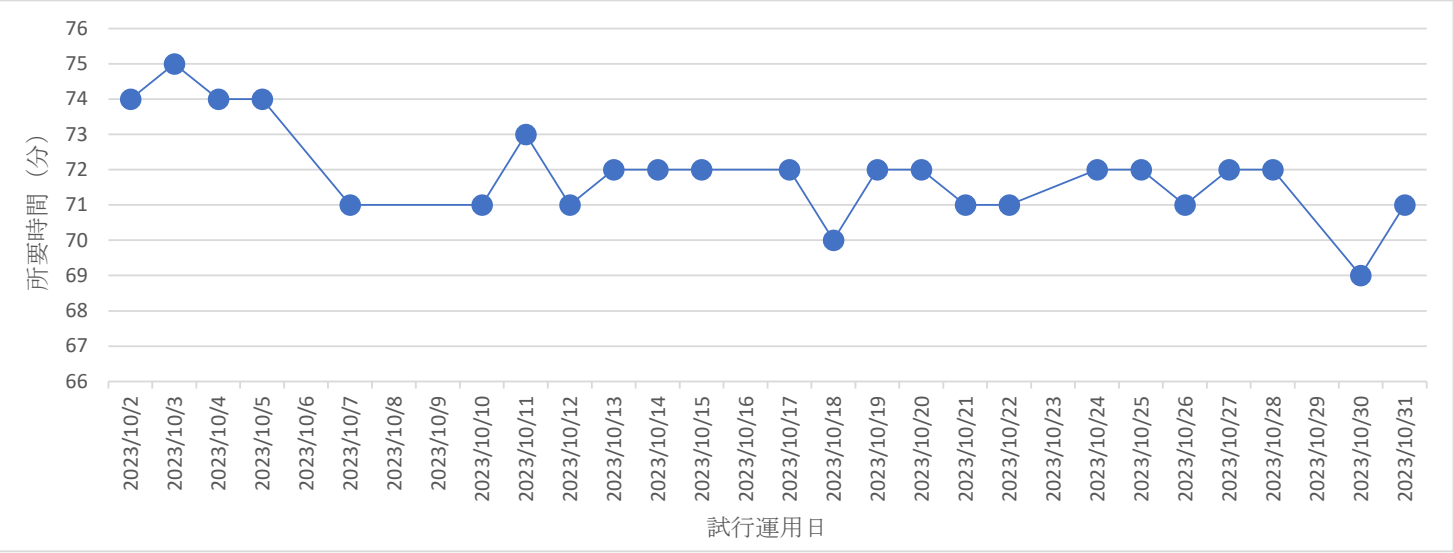
(b) Verification of consistency between proposed and implemented locations

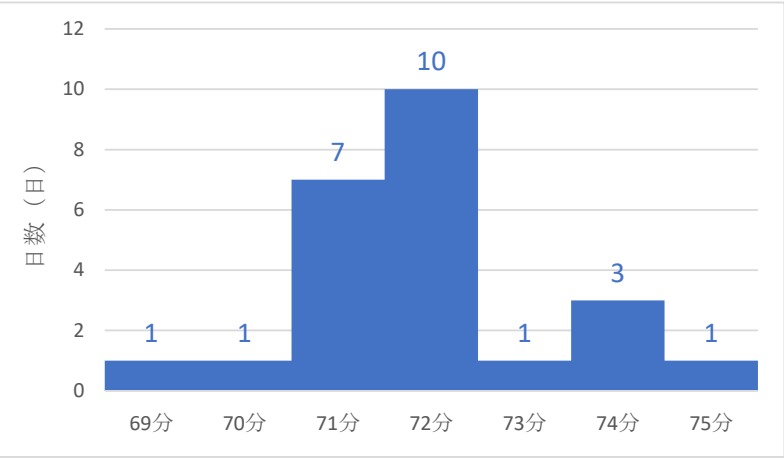
- During the trial operation, the system proposed 12 locations. **4** of the 12 locations have a **100% implementation rate**, and **6 have an implementation rate of 80% or higher**.
- Few proposals were made by the system along Koshu-kaido road and were implemented in non-proposed areas at the discretion of the police officers.

(3) Verification of convenience

a) Processing time of the system

- The time required for the simulation is between 69 minutes ~ 75 minutes, and the result is that the blur is small.
- **71.9 minutes on average**、The maximum frequency 72 minutes, and the standard deviation 1.35 minutes.





Statistics	time
Average	71.9 min
Mode	72 min
Maximum Value	75 min
minimum value	69 min
Standard deviation	1.35 min
Number of trial days	24 days

(3) Verification of convenience

b) User opinion

- Regarding the overall picture and direction of the system, the results showed a high level of satisfaction among users (police officers).
- Collected opinions and suggestions for improvements to the operability of the system and the proposed parts.

Convenience and operability	○	• The ease of viewing and **basic operability** of the screen were satisfactory
	×	• Regarding the display content, request to **add the address and intersection name of the recommended place** • Request to **reduce the number of operations**, such as automatically deleting pop-outs that have already been entered. • Request frequently used tabs to be pinned all the time.
Opinion on the model	○	<u>About the proposed location</u> • A major intersection was proposed, and it was **generally in agreement with the police's perception** • Locations where they do not normally work were also proposed, and it was possible to **prevent police officers from getting into a rut.** • The proposed location changed between the beginning and the end, and I felt that the street activities had an effect
	×	<u>Opinion on the proposed location</u> • **Since the history of accidents at the proposed site is unknown,** details such as where to stand will be determined at the site. • **A point where there is no place of activity was proposed** • When the same location was proposed every day, the sense of satisfaction with the proposal decreased. • Couldn't find a proposal for a place to do the activity.
	other	<u>Desire for additional features</u> It is easy to use if the proposal is for a **certain period of time, such as one week**. It would be desirable if there was a function to **improve the efficiency of activities**, such as obtaining the same effect with a small number of places →At the time of verification, we proposed it for 4 locations per day, but the same effect can be obtained at 3 locations
Impressions	-	• It is a **reference** for determining the layout of the street, and I would like to **continue using it** • Felt that it would be easier to use if it could be linked with other police systems.

5. How the system is made available to the public

5.1 Methods of releasing the Traffic Guidance and Enforcement Activity

Since FY2022, we have been working on building a system under the "Research on Efficient Accident Prevention Measures Using Artificial Intelligence" project. This system will be owned by the International Association of Traffic Safety Sciences, with the assumption that it will be open to the public.
Since the system construction will be completed this fiscal year, we examined the method for opening the system to the public starting next fiscal year, based on the following requirements.

〈Requirements〉

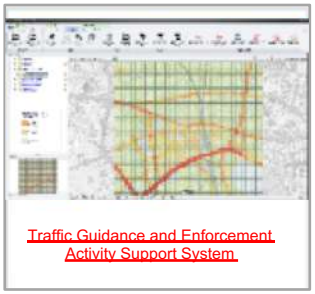
- The method of acquisition must be publicly available.
- The system should be open to anyone (organization) interested in the system.
- A record must be kept of when and by whom it was acquired.
- The impersonation of the acquirer (organization) is not likely to occur.

〈Publishing Method〉

- The system will be placed on a DVD or other medium and mailed to the client.
- The cost of mailing is paid by the acquirer.
- Application will be obtained on the IATSS website.
- Applicants need to fill in the name of the organization, the name of the individual, and the address.

5.1 Methods of releasing the Traffic Guidance and Enforcement Activity

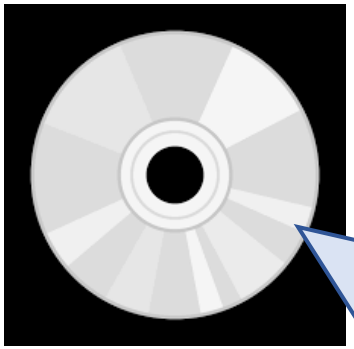
〈Newly added〉



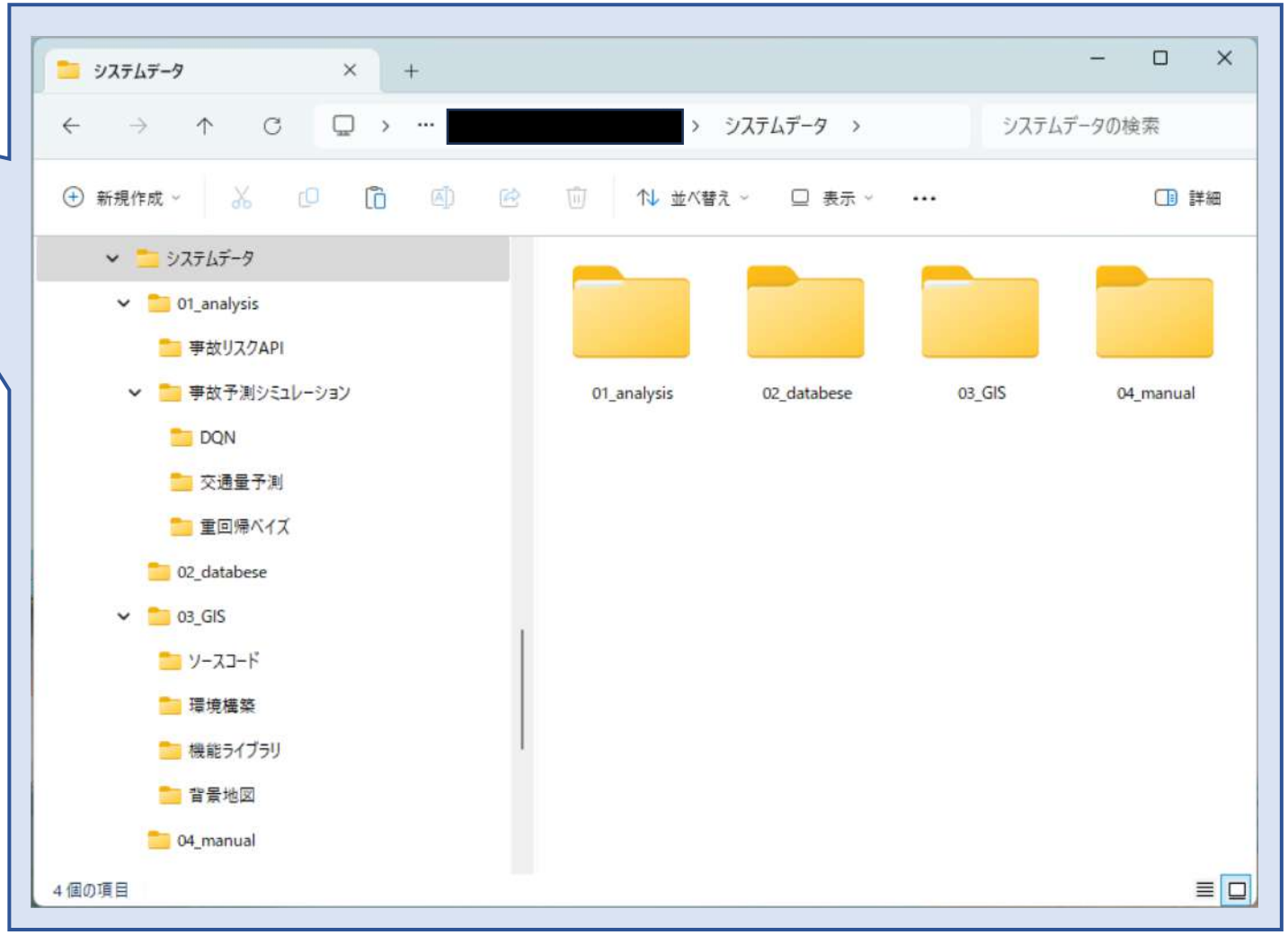
Traffic Guidance and Enforcement Activity Support System

<Newly built page>.

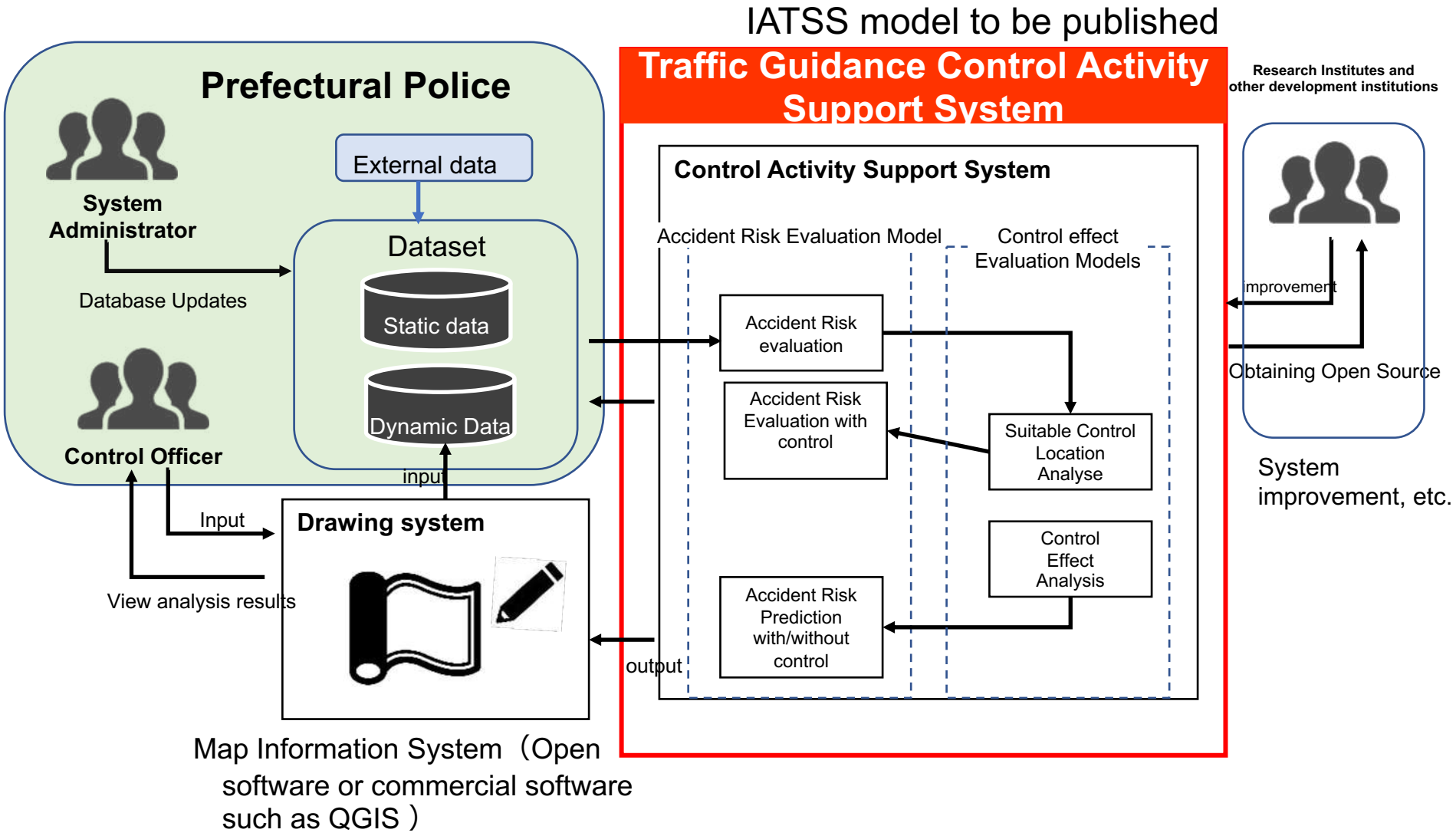
〈Distribution disk〉



<System data image stored in the system



Operational image of the public system



公益財団法人 国際交通安全学会

International Association of Traffic and Safety Sciences