Japan Clean Air Program

Further Challenge in Automobile and Fuel Technologies For Better Air Quality

JCAP I Overview and JCAP II Plans

October 9-10, 2002

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http://www.pecj.or.jp/jcap/index-jcap.htm

for Joint Meeting ; APBF-DEC,CAFE,JCAP

What is JCAP?

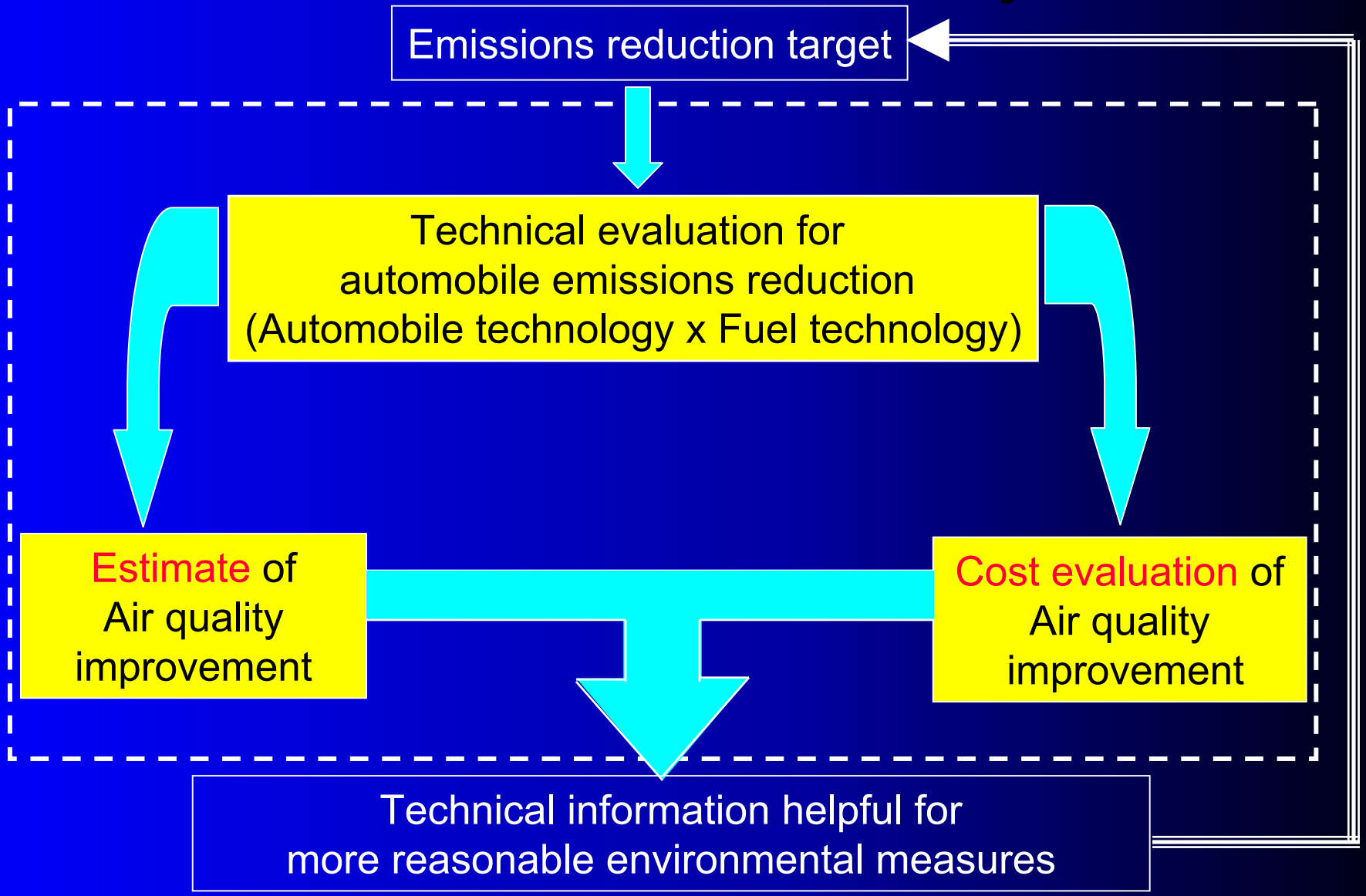
(Japan Clean Air Program)

- Collaborative study by automobile industry and petroleum industry
  (Supported by METI's subsidy)
- JCAP I has been conducted for 5-years from 1997 to 2001
- JCAP II has been launched as another 5-years plans from this year

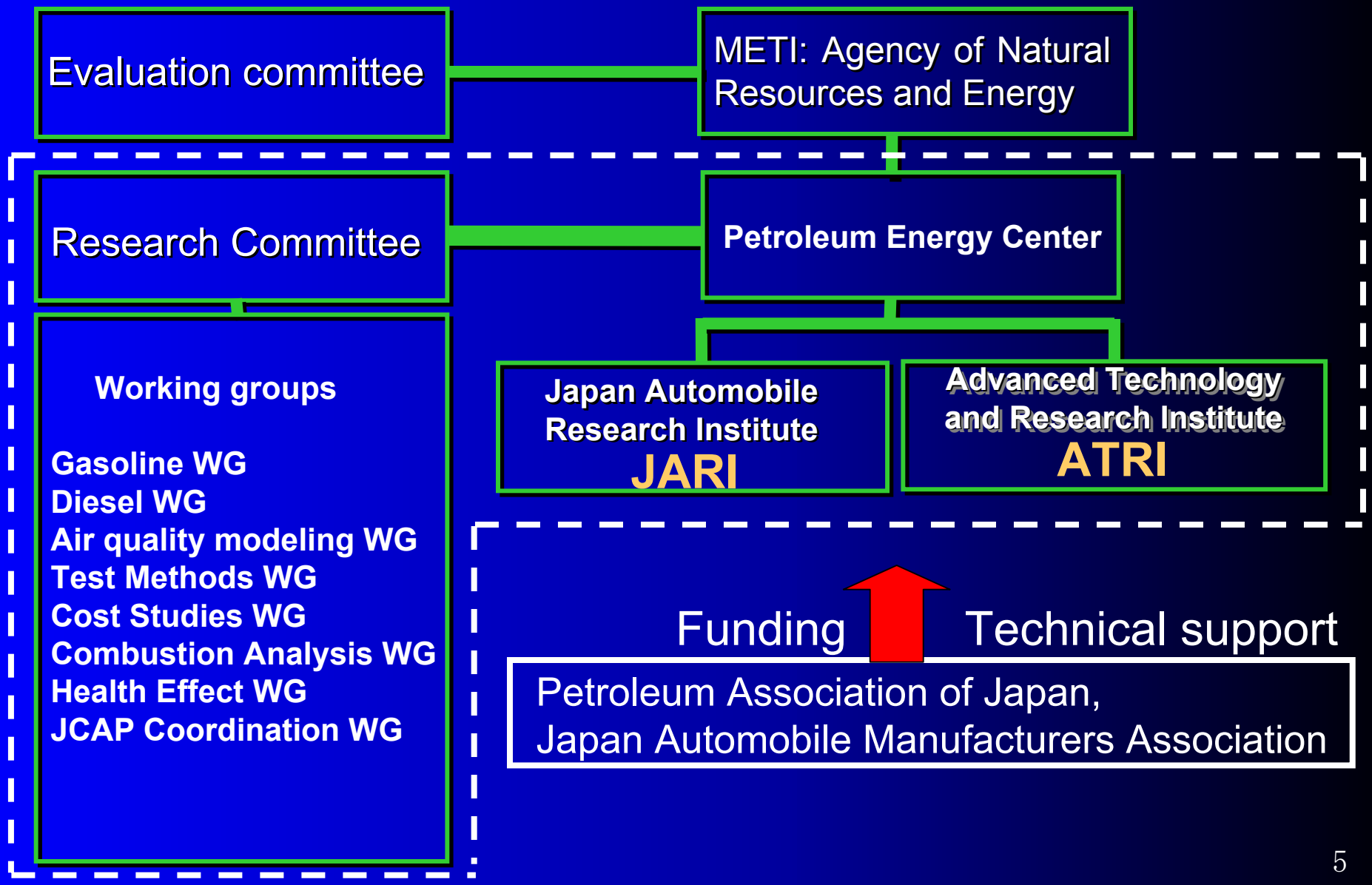
Background

- Stringent requirement for automobile emission reduction
  - Further cooperation between automobile and fuel technologies is required.
- Auto & Oil corporation program in Europe and the U.S.A.
  - the U.S.A.
    - AQIRP (Air Quality Improvement Research Program)
    - APBF-DEC (Advanced Petroleum Based Fuel-Diesel Emission Control)
  - Europe
    - Auto Oil I & Auto Oil II
- Independent study proper to Japan is required.
  - Difference in automobile employment conditions (emission measurement mode, etc.)
  - Introduction of advanced automobile technologies (Gasoline vehicle with lean burn, direct injection type engine, etc.)
  - Circumstance difference of fuels (gasoline and diesel fuel quality)

Correlation of Three Objectives



JCAP Organization



Schedule

	STEP I (1997,98)	STEP II (1999-2000)
Technical evaluation	Existing vehicle with existing fuel	Future vehicle with future fuel
Atmospheric effect evaluation	Base model creation	Prediction and verification with models
Economy evaluation	Evaluation methodology study	Research and analysis

Results of JCAP I (1)

WG	Role
Test Methods	-The reliability of test data obtained from Gasoline/Diesel WG tests was ensured. -Measurement methods for fine particulate matter emitted from automobiles were studied and unresolved issues were clarified.
Gasoline	-Reduction of sulfur content in gasoline had an effect on exhaust emission reduction, however, it was suggested that sulfur influence varied with exhaust emission control systems. It was clarified that reduction of evaporative emissions had effects on canister capacity increase and RVP reduction.
Diesel	-Since sulfur content had the most important influence on fuel quality for after-treatment technology, reduction of sulfur in diesel fuel to 50 ppm max. was necessary to meet with the requirements of New Long-term regulations. -Survey on fine particulate matter reduction technologies for in-use vehicles was conducted, and measures were advanced. Engine oil influence on continuous regeneration type DPFs was clarified.
Combustion Analysis	-Combustion analysis with single cylinder engine was carried out and influence of fuel properties was clarified. -Statistical analysis method with a concept of residual density was used, so that influence of fuel density and aromatics was clarified.

Gasoline WG

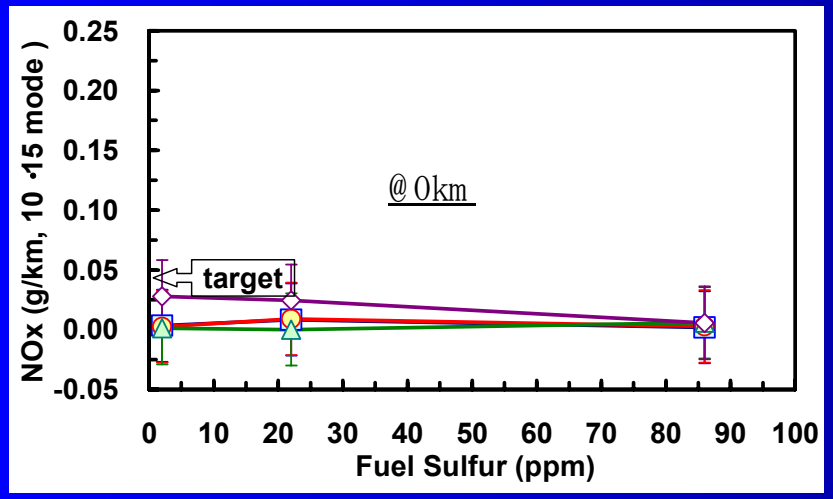
Influences of sulfur （after 30000km aged）

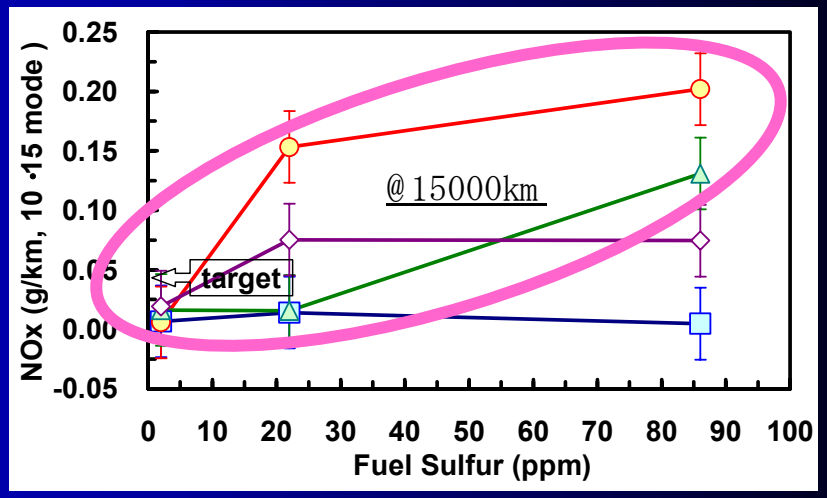
Mode		10・15			11		
Sulfur change, ppm		86→22	86→2	22→2	86→22	86→2	22→2
CO	GVA(MPI)	→	→	→	→	→	→
	GVB(SIDI)	→	→	→	→	↓	→
	GVC(SIDI)	→	→	→	↓	↓	→
	GVD(SIDI)	↓	↓	↓	↓	↓	↓
THC	GVA(MPI)	↓	↓	→	→	→	→
	GVB(SIDI)	↓	↓	→	→	↓	↓
	GVC(SIDI)	↓	→	→	↓	↓	→
	GVD(SIDI)	↓	↓	→	→	→	→
NOx	GVA(MPI)	→	→	→	↓	↓	→
	GVB(SIDI)	→	↓	↓	→	↓	↓
	GVC(SIDI)	↓	↓	→	↓	↓	→
	GVD(SIDI)	→	↓	↓	↓	↓	↓

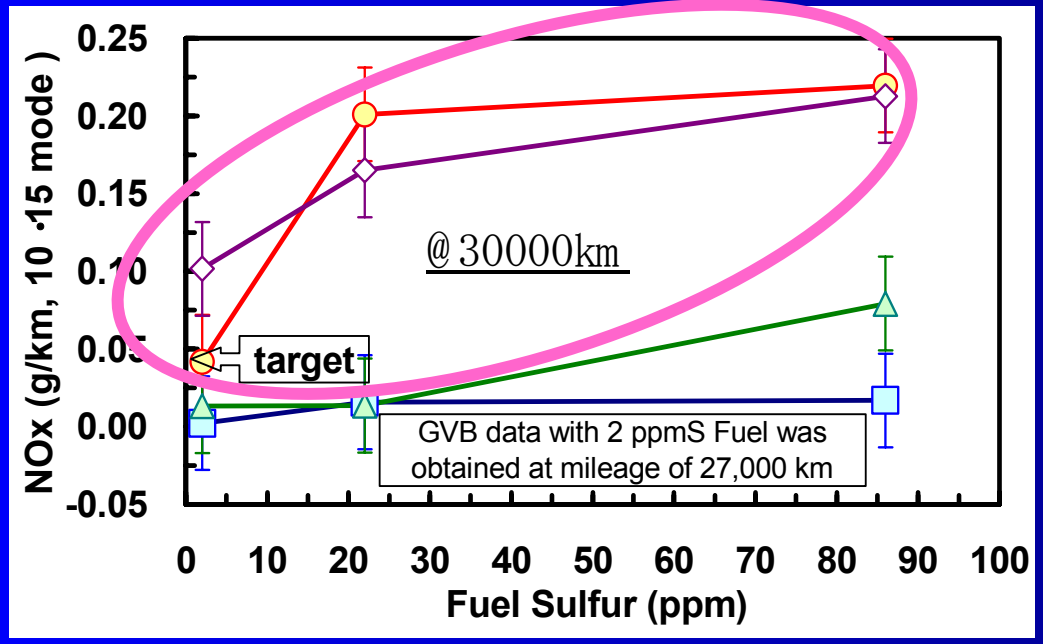
→ : No Change　↓ : Decrease

- **Exhaust emissions are improving with sulfur reduction.**
- **SIDI vehicles tend to be more influenced by sulfur than MPI vehicles**

Test results<10・15mode・NOx vs. Sulfur>







GVA（MPI-3-way cat）
GVB（SIDI-NOx Storage & Red. cat.）
GVC(SIDI-NOx Storage & Red. cat.）
GVD(SIDI-NOx Reduction catalyst)

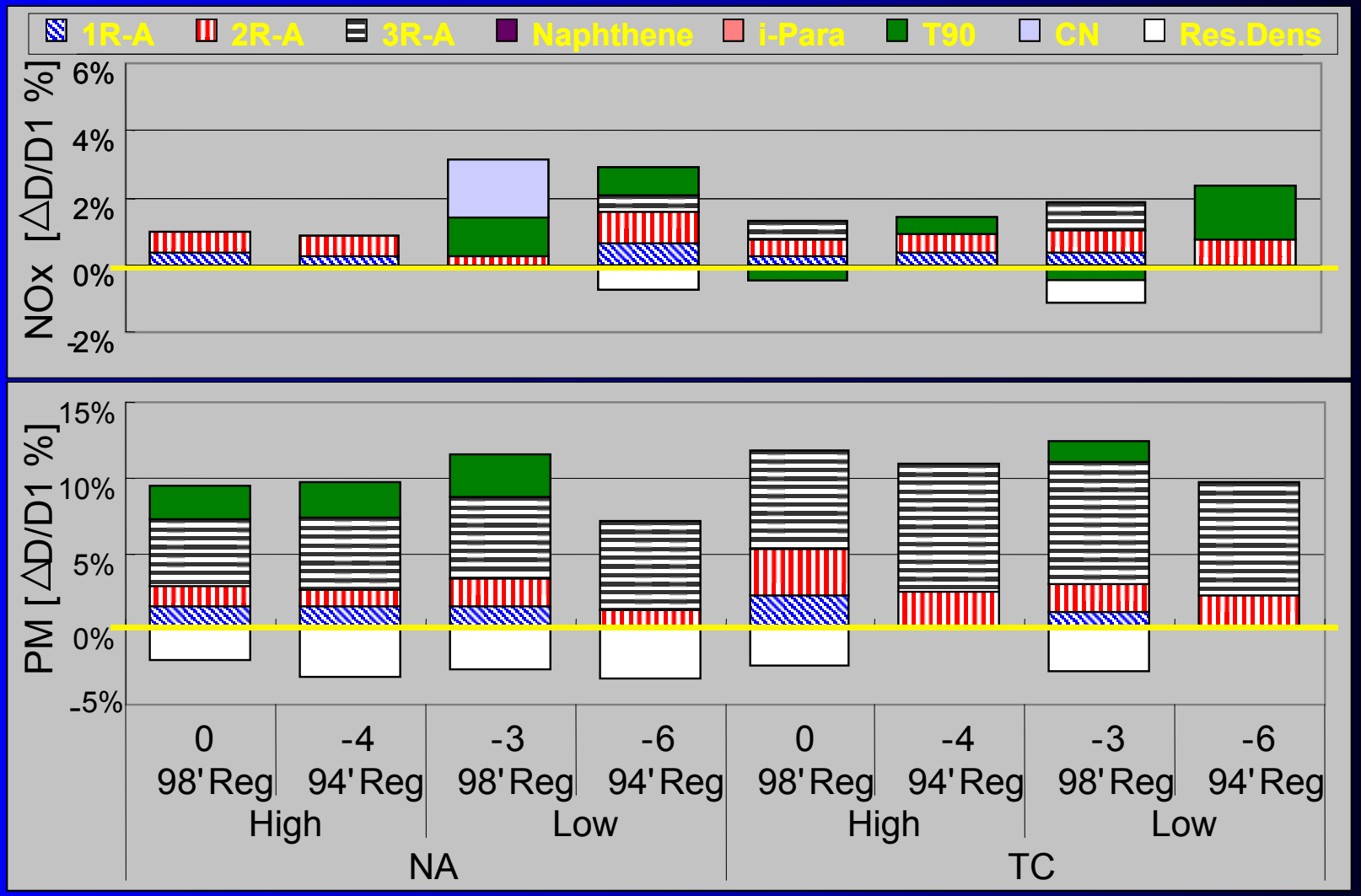
- **At 0km, no vehicle showed Sulfur influence.**
- **At 15000 and 30000km aged, SIDI showed sulfur influence. GVB and GVD showed a large influence.**
- **GVC showed an influence with sulfur reduction from 86 to 22ppm and no influence from 22 to 2ppm respectively.**
- **GVA（MPI）showed no sulfur influence.**

Mileage Accumulation

Combustion Analysis WG

Impacts, by range of fuel properties change in market place

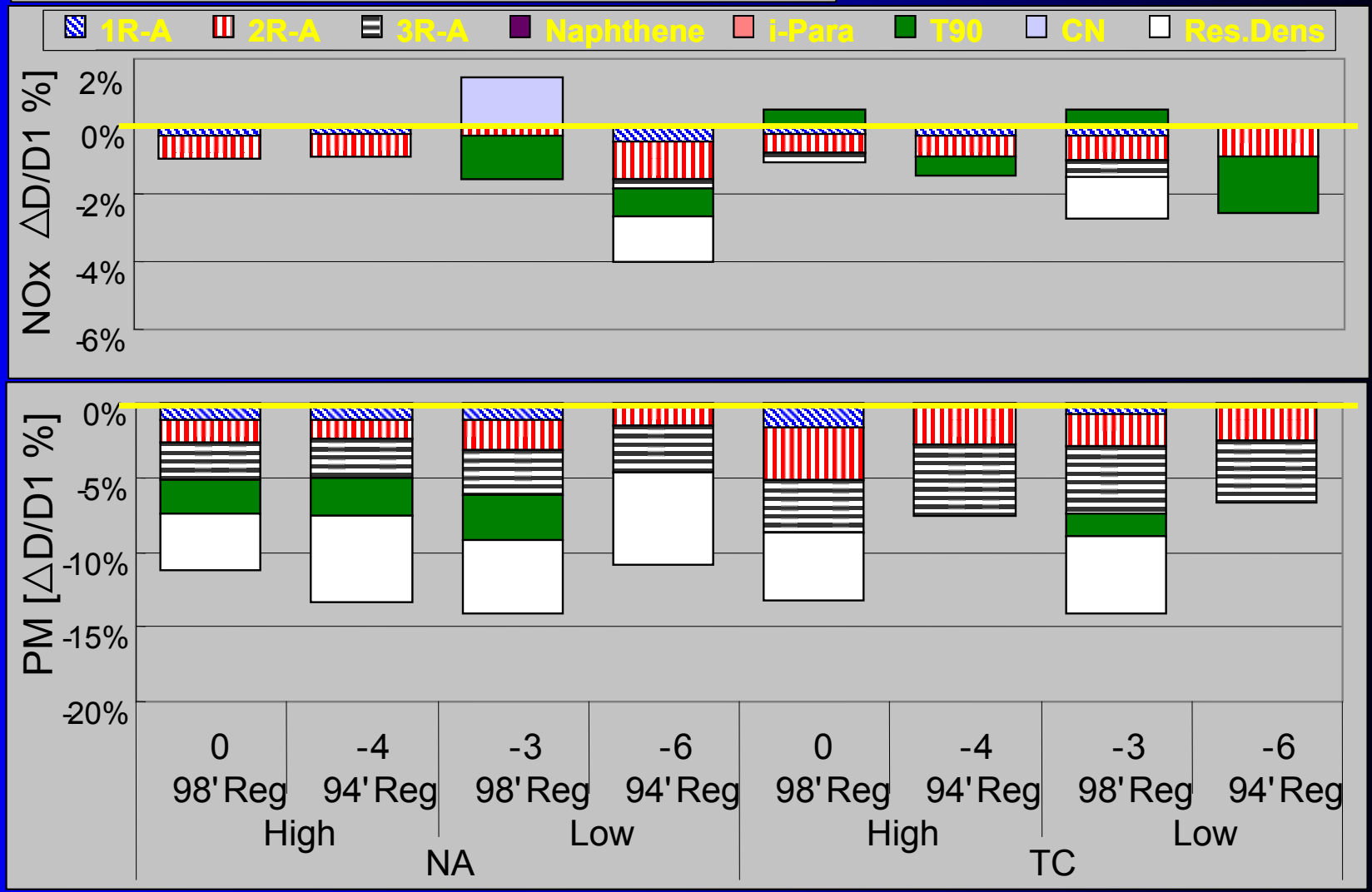
D5 fuel…High Aroma., High T90



Combustion Analysis WG

Impacts, by range of fuel properties change in market place

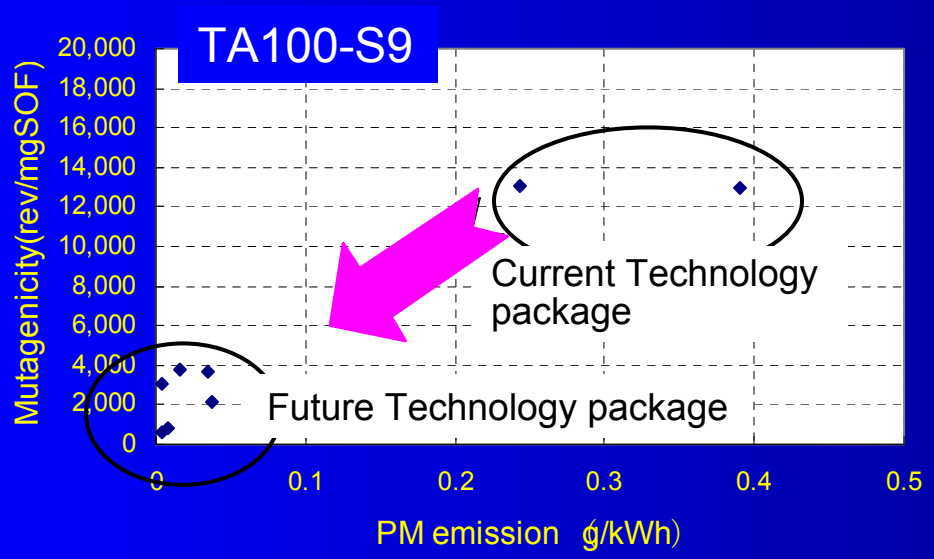
D2 fuel…Low Aroma., Low T90

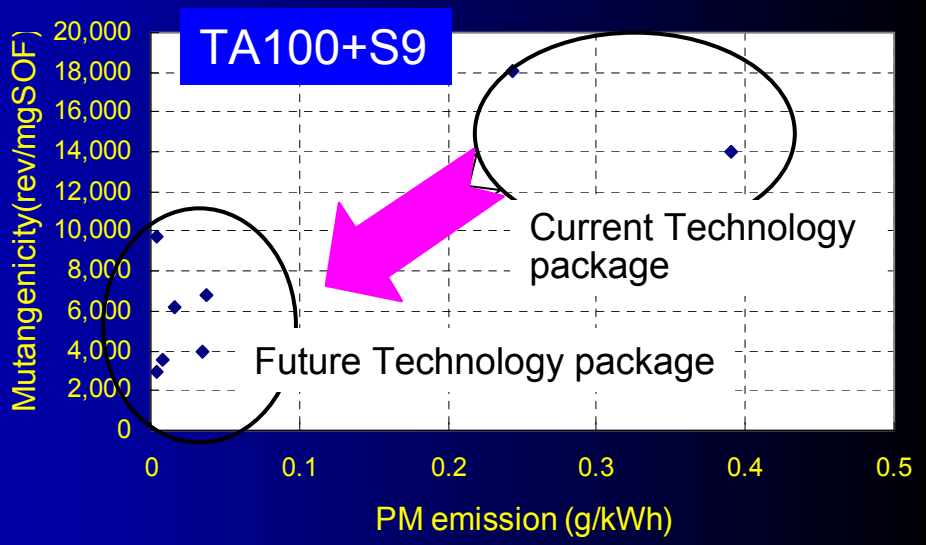


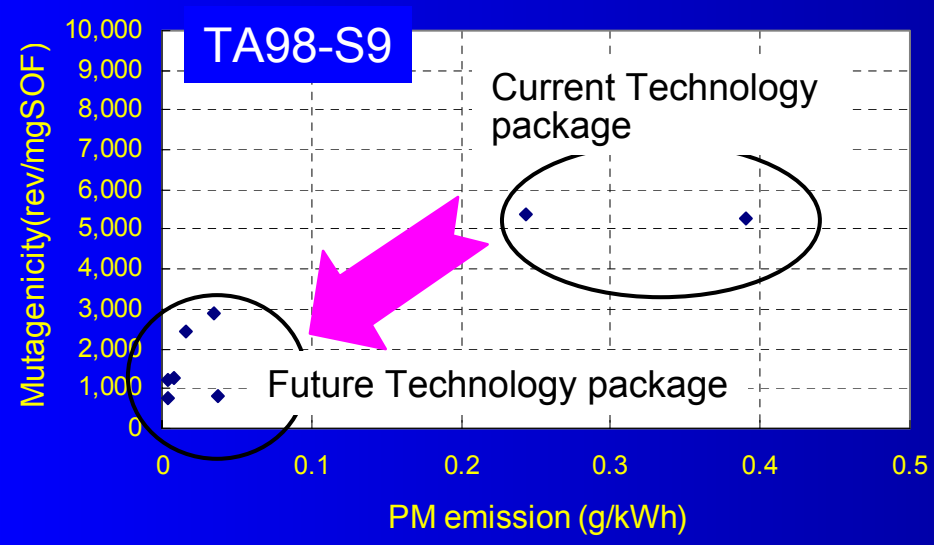
Results of JCAP I (2)

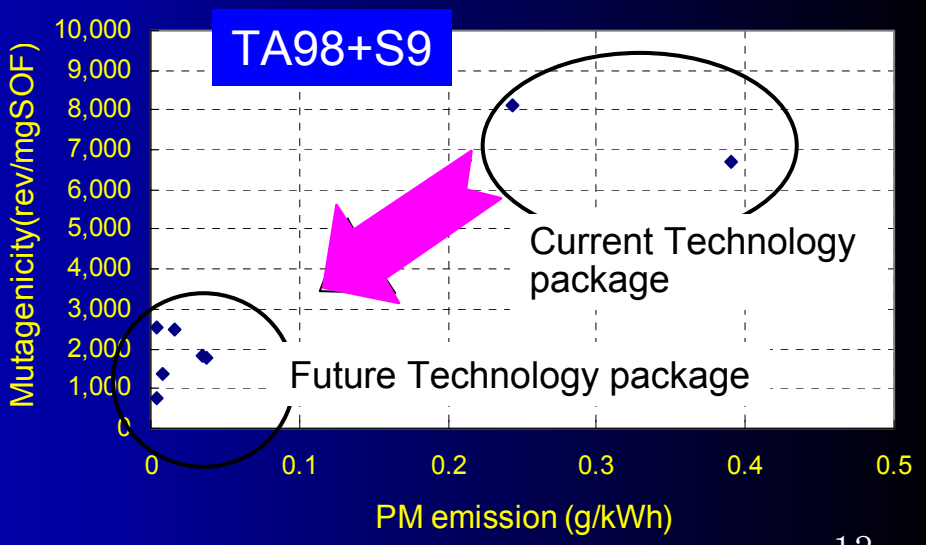
WG	Role
Health Effects	-Ames test on SOF was carried out to study health effects improvement due to the exhaust emission reduction measures for automobile fuels. -Gather scientific information on health effects of exhaust emissions from automobiles, and summarize information on risk assessment of human health.
Air Quality Modeling	-Development of models: automobile exhaust emission inventory simulation model including cold start emissions and evaporative emissions, transient emission inventory simulation model around crossings in consideration of traffic flow, roadside diffusion model based on LES, second organic aerosol model with high accuracy. -High concentrated air pollution around crossings in metropolitan area of Kanto area was simulated with these models, and improvement due to the introduction of New Short- and Long-term Regulations was evaluated.
Cost Studies	-Cost effects of automobiles and fuels required for exhaust emission reduction measures were clarified.Environment awareness and cost acceptance of consumers and industries were surveyed, and the intention of consumers and industries were clarified. -A suggestion was made; the introduction of various economic techniques was effective and necessary for early popularization of low emission vehicles .

Comparison of Mutagenicity (Engine)

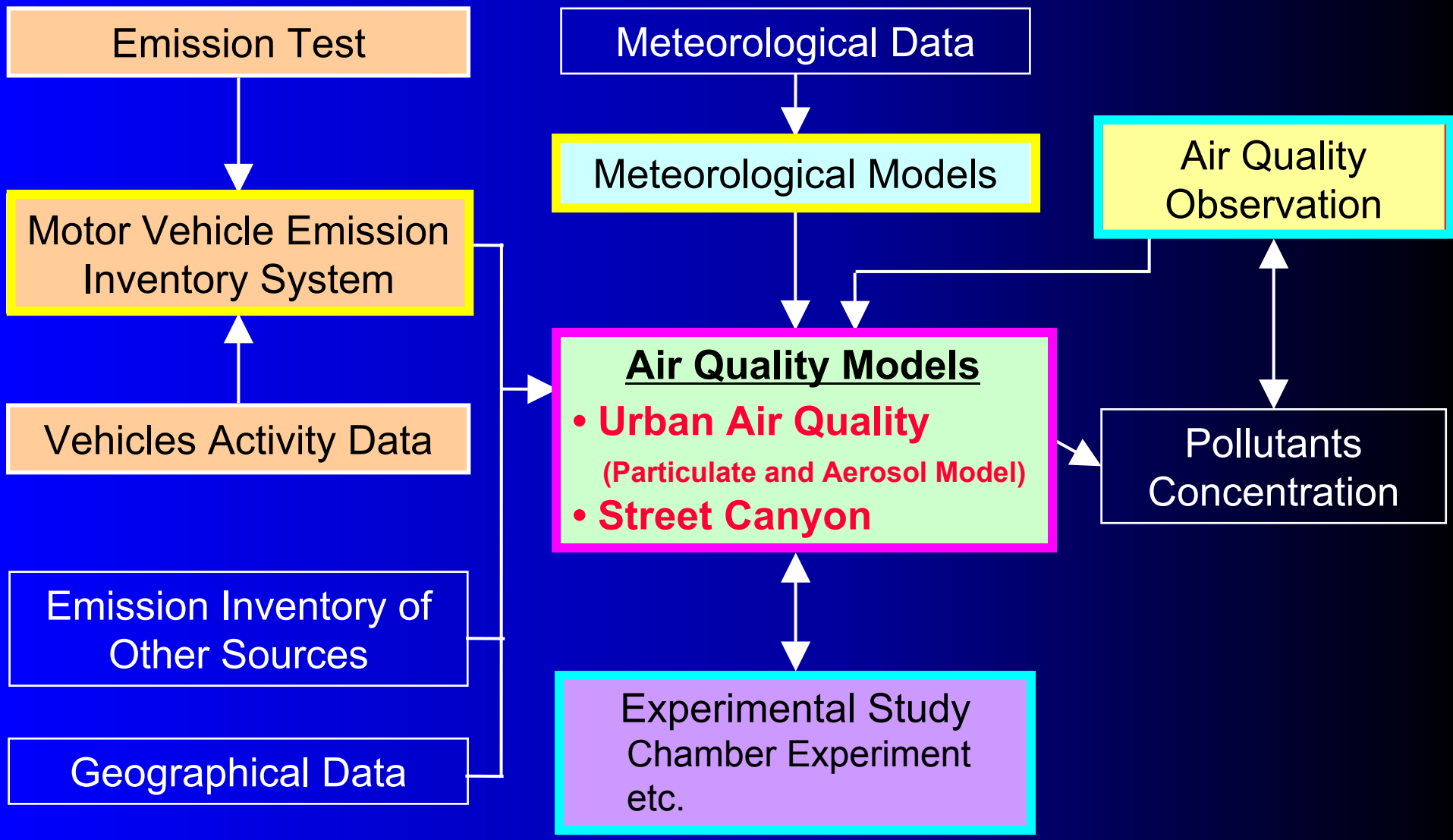




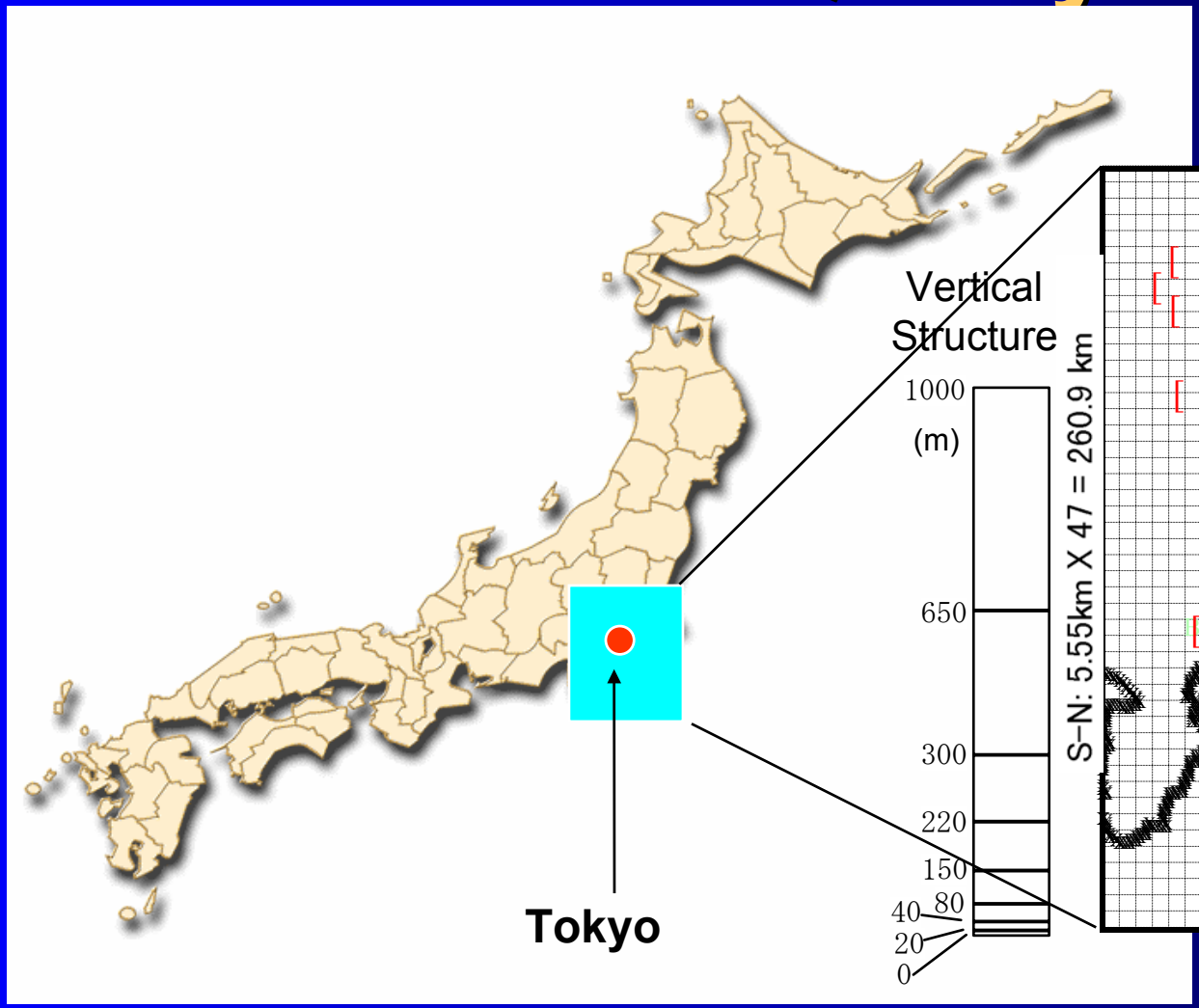




Air Quality Studies in JCAP

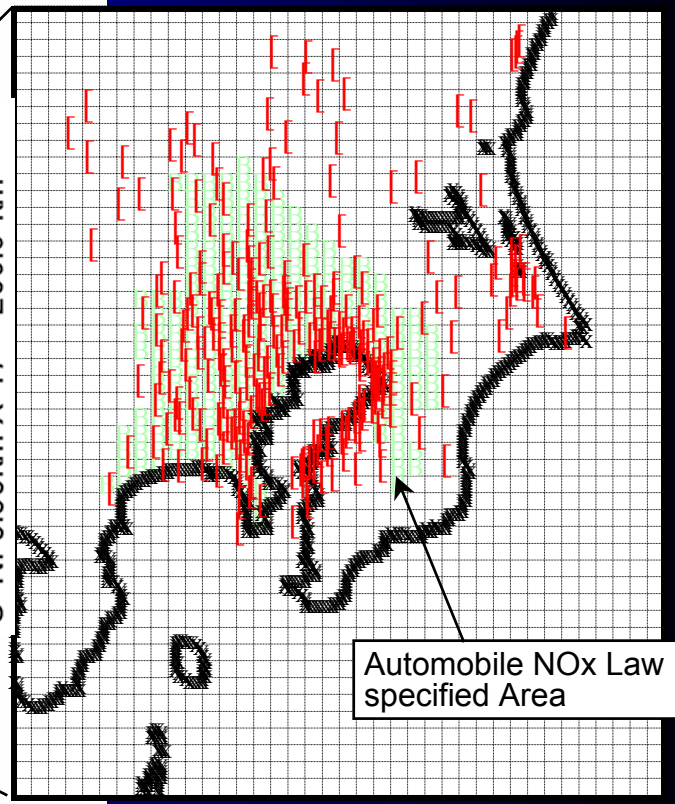


Modeling Domain for Urban Air Quality Simulation



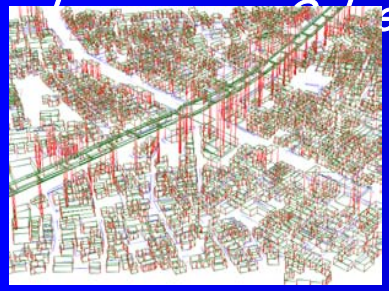
Vertical Structure

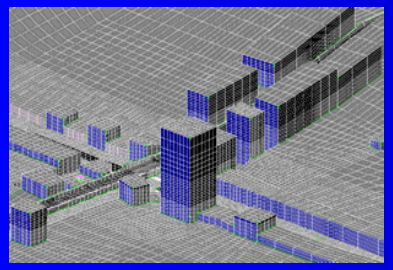
Grid for CIT Model (Winter Season)

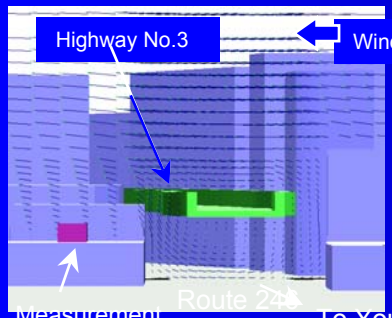


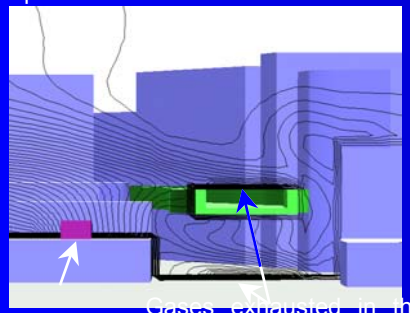
■ Air Quality Monitoring Stations

Development of 3D Roadside Model









Shape data of buildings along the road

Calculation matrix

Air stream model

Air stream field in roadside

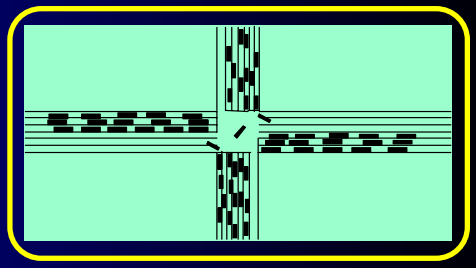
Advection diffusion model

Diffusion concentration field of automobile exhaust in roadside

Concentration field in roadside

Traffic parameters in roadside (road layout, signal configuration, traffic amount, etc.)

Micro scale traffic flow model

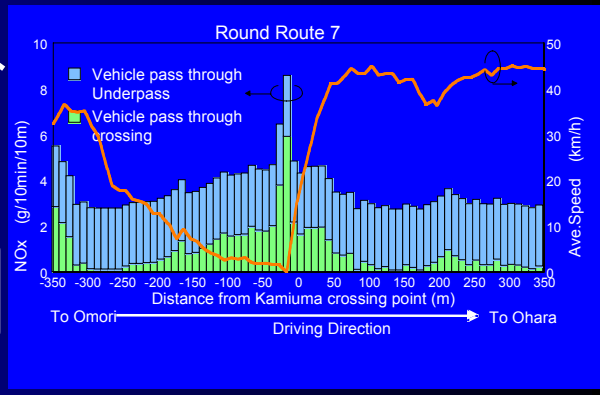


Traffic flow in roadside (All vehicles' positions/speed/acceleration at every second)

Transient emission coefficient

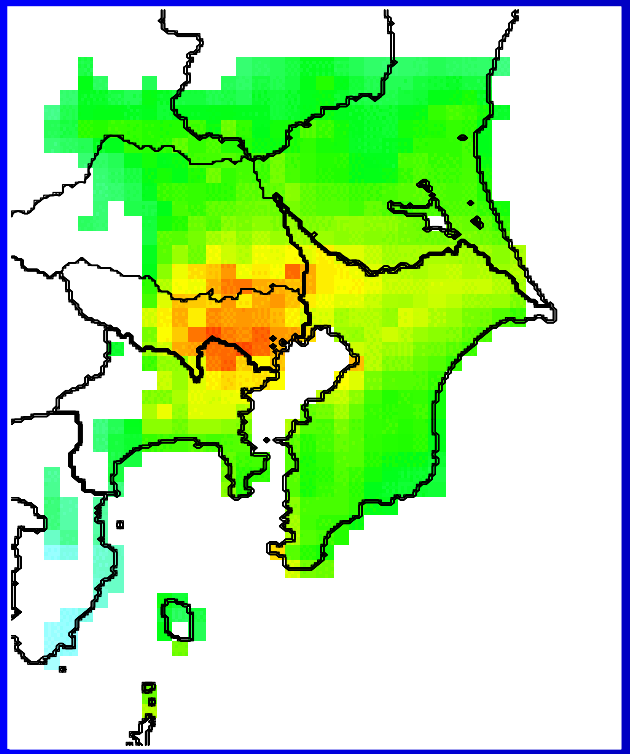
Exhaust emission distribution in roadside

Background concentration by wide area

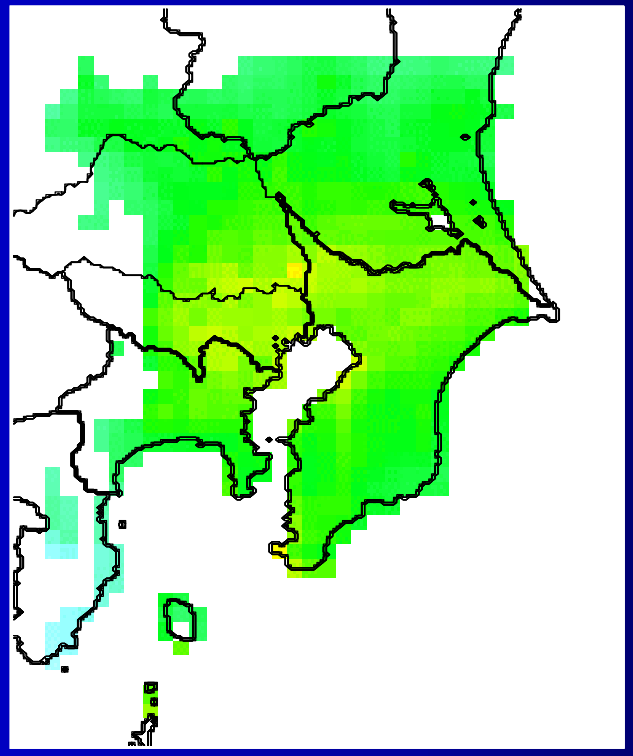


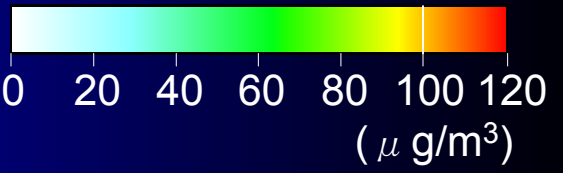
Effect of Vehicle Emission Reduction and SPM Concentration (Year 2000→2015)

Year 2000



Year 2015





(Average per day in 2015 : Example of introduction of New Short-term and Long-term regulations)

The reduction effect in Metropolitan area is large and approx. 30% Max.

Summary of JCAP 5-year-activities

Achievements;

-Consensus between Automobile and Petroleum industries

-Obtained fair data for open issues

-Established a world-class Air Quality Modeling

Presentation at the JCAP Conference

-Contribution to policy making
(Comments to regulatory affairs, rule making and so on.)

Concerns;

-Confidentiality of technical information and difficulties with technical
- analysis

-Gap between the discussion at rule making process and progress in researches

Reflection;

-Succession of the JCAP achievements

-Evaluation of CO2 reduction technologies

-Enhancement of technical investigation

-Improvement of activity administration
- (Separation of technical evaluation, focusing of research activities)

Major publication activities

	'97	'98	'99	'00	'01	'02
Report to the Central Environmental Council (Expert Committee for Motor Vehicle Exhaust Emission)		▼	▼		▼	
Petroleum Products Quality Sub-committee of Advisory Committee for Natural Resources and Energy						▼
Hearing at Evaluation Committee of Diesel vehicle Emission Control technologies				▼		
JCAP Conference		▼No1		▼No2		▼No3
Cooperation with foreign organizations					▼ JRC	▼ NREL

Reflection to JCAP II
(Role to Regulatory Affairs)

Contribution to environment and energy policies through Fair Data

Environment policies = Energy policies

Forecast for petroleum quality, supply and demand

Prospects of Air Quality improvement effects such as automobile emission reduction

Direction of future automobile technologies and the required fuel quality

Emission inventory estimate in real world in the future

Researches on Air Quality Modeling with high-grade accuracy and database establishment enabling to evaluate policies

Researches on automobile and fuel technologies aimed at realizing Zero emission (compatible with CO2 emission control measures)

Reflection to JCAP II
(Succession of the JCAP achievements)

Achievements of JCAP activities(from 1997 to 2001)

(For New Long-term regulations)

- Clarified fuel quality effects on automobile technologies.
- A Consensus for the necessity of 50ppm sulfur content diesel fuel.
- Evaluation of vehicles emission control measures to Air Quality.

(Air Quality Modeling developed by JCAP is recognized as world-class)

Intention of Next Generation JCAP: Fuel technologies and automobile technologies aimed at Zero-emission and fuel consumption improvement will be clarified, and a potential for realizing low-pollution vehicles will be evaluated.

Automobile industry: Proposal for emission and fuel consumption control regulations will be offered in cooperation with Petroleum industry.

Petroleum industry: Quality improvement and stable supply of fuels and oils will be ensured in cooperation with Automobile industry.

Government:Information on technologies required for examining policies for Air Quality improvement will be obtained.

Outline of JCAP II activities

1. Purpose Fuel technologies and automobile technologies aimed at Zero-emission and fuel consumption improvement will be clarified, and a potential for realizing low emission vehicles will be evaluated.

2. Budget 5.6 billion yen for 5 fiscal years incl. 4.4 billion yen of subsidy from METI

3. Duration from FY 2002 to FY 2006

4. Organization

JPEC: Supervision of the project
Development of Air Quality Modeling
Implementation of researches

PAJ & JAMA:
Share for fund

Automobile manufacturers & Oil companies:
Offer of technologies, implementation of researches

METI: Ministry of Economy, Trade and Industries
JPEC: Japan Petroleum Energy Center
PAJ: Petroleum Association of Japan
JAMA: Japan Automobile Manufacturers Association

JCAP II Project

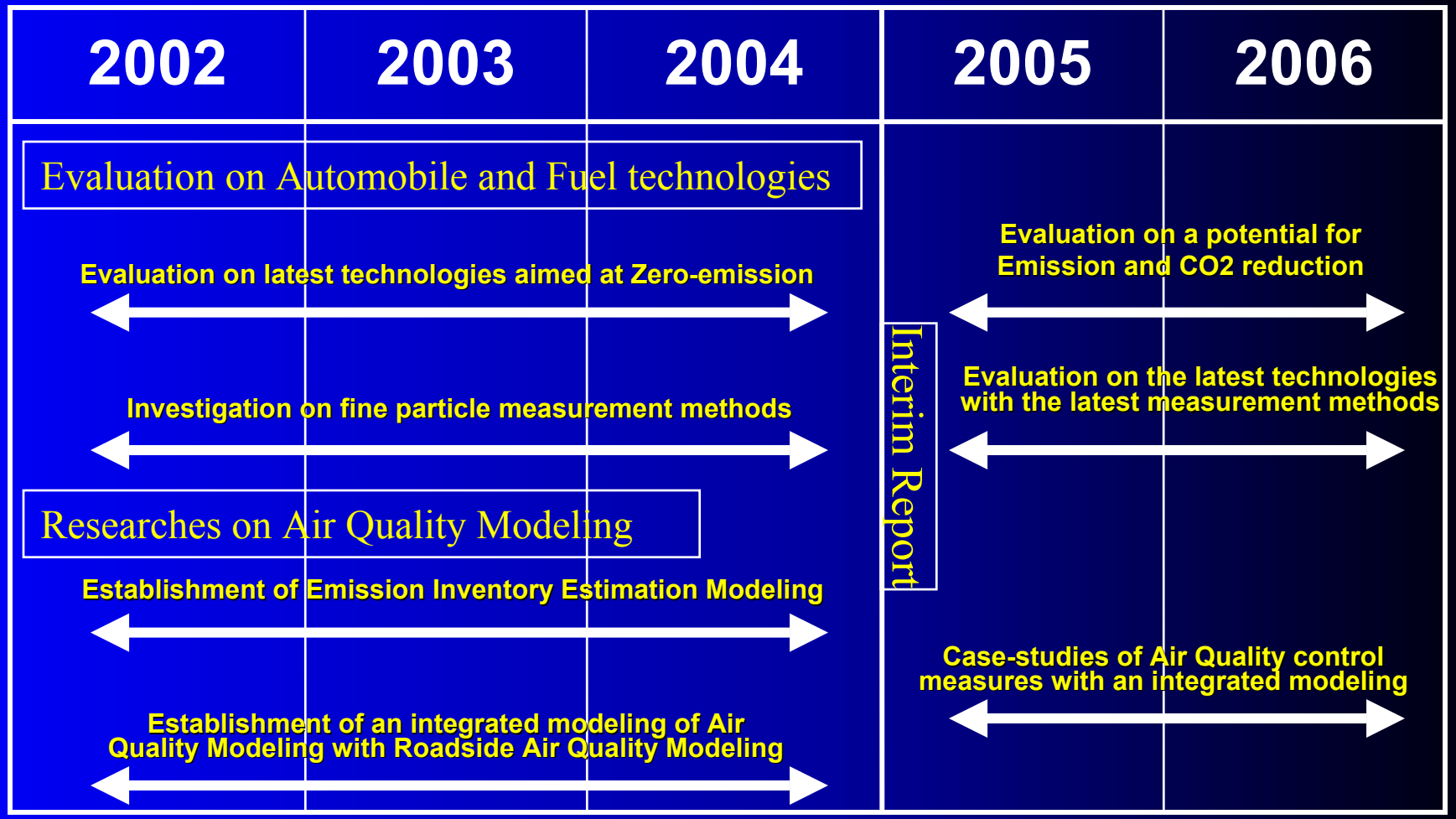
(1) Researches on Automobile and Fuel technologies

- Evaluation on Gasoline and Diesel-powered vehicle's latest technologies aimed at Zero-emission and fuel & engine oil properties
- Evaluation on a potential for emissions and CO2 reduction
- Investigation on fine particle measurement and evaluation on the latest technologies with the latest measurement methods

(2) Researches on Air Quality Modeling

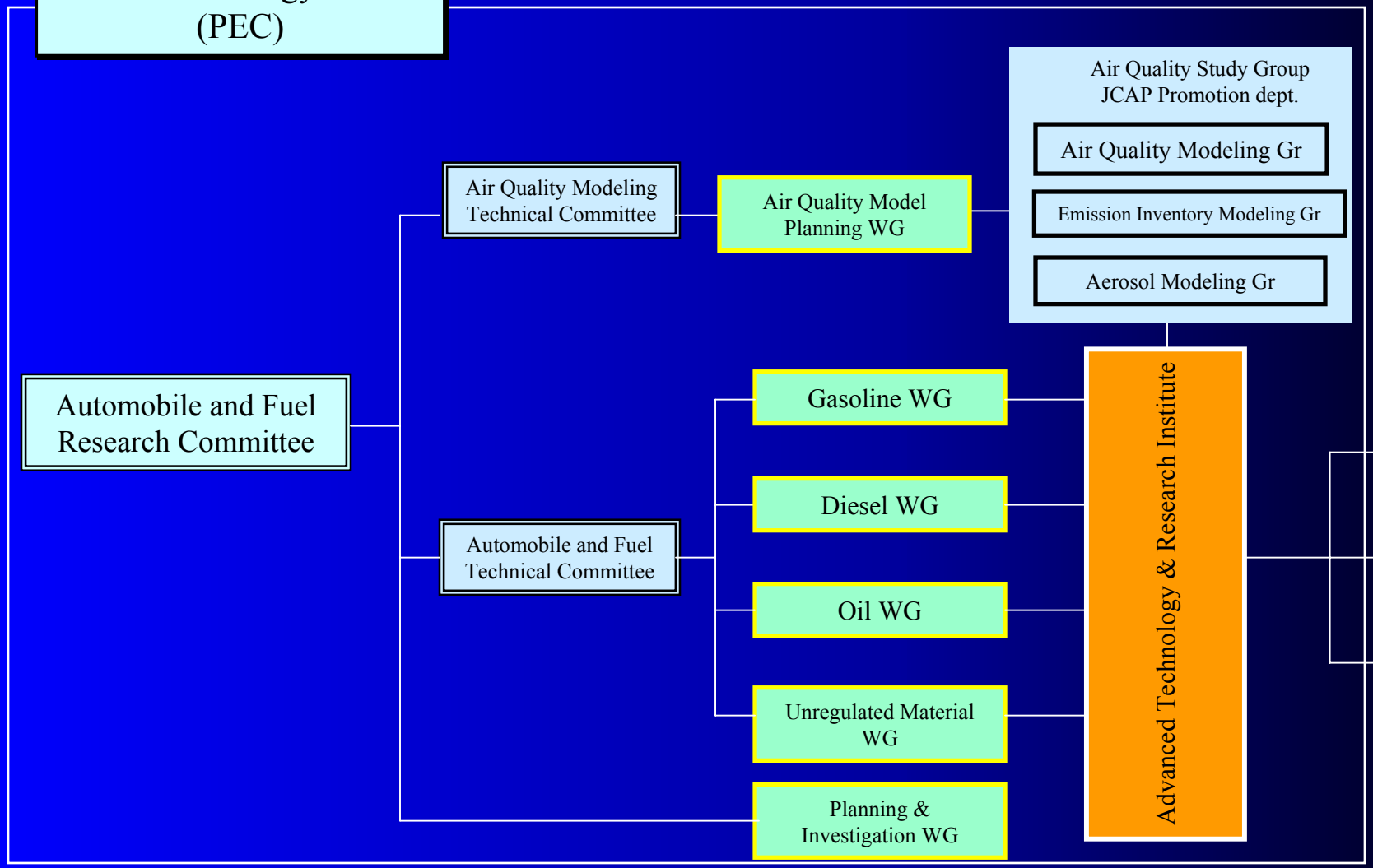
- Establishment of Emission Inventory Estimation Modeling in real world
- Establishment of an integrated modeling of Air Quality Modeling with Roadside Air Quality Modeling
- Case-studies of Air Quality control measures with an integrated modeling

JCAP II Schedule



Organization Chart of JCAP II

* Ministry of Economy, Trade and Industry
** Japan Automobile Research Institute



Role & Function of Working Groups

Working Group Name	Role & Function
Planning & Investigation WG	a. Examine the direction of whole JCAP II activities b. Coordinate with other organizations required for forwarding the research activities. c. Investigate technologies relative to the activities of WGs, and support their study. d. Establish sub working groups if required for the activities.
Air Quality Model Planning WG	a.Examine a development direction of Air Quality Simulation Models that enable to evaluate an influence of automobile exhaust emission reduction measures on air quality. b. Predict the influence of automobile exhaust emission reduction measures on air quality with air quality simulation models, and provide suggestions for future air quality improvement.
Gasoline WG	a. Evaluate and analyze the exhaust emission reduction potential of gasoline engine and fuel technologies aimed at realization of zero emissions, and clarify future exhaust emission reduction measures.
Diesel WG	a. Evaluate and analyze the exhaust emission reduction potential of diesel engine and fuel technologies aimed at realization of zero emissions, and clarify future exhaust emission reduction measures.
Oil WG	a. Evaluate and analyze the oil influence on engine and fuel technologies and exhaust emission after-treatment devices aimed at realization of zero emissions, and clarify future exhaust emission reduction measures.
Unregulated Material WG	a. Compare and examine the measurement methods for fine particles and unregulated material in exhaust emissions, and clarify the reasonable measurement methods. b. Clarify the influence of engine and fuel technologies aimed at zero emissions on fine particles and unregulated material.

Outline of Gasoline WG Activity Plans

No	Subject	Expected results
1	Examination on fuel property influence for gasoline vehicles	-Grasp fuel properties effects on vehicle emissions with the latest technologies -Grasp effects of sulfur content on emissions and fuel consumption
2	Emission reduction and fuel consumption improvement potential evaluation	-Grasp emissions and fuel consumption (CO2) under a wide range driving conditions in the combination of fuels and engines selected from the results of No.1
2‘	Combustion analysis based on the test results, etc.	-Clarify effects of fuels and automobile technologies by forwarding further analysis on combustions, etc. based on the results obtained by fuel matrix test
3	Effect evaluation of deposit from SIDI, fuel properties and additives on emissions	-Grasp a relationship between deposits and emissions based on the test method developed by OACIS. -Grasp deposit effects originated from fuel and additive properties on emissions.
4	Grasp of optimum octane number	-Clarify optimum octane number in view of total CO2 emission inventory from refinery to engine out

Outline of Diesel WG Activity Plans

Subject	Expected results
Potential evaluation of exhaust emissions and CO2 reduction with the latest diesel technologies and the ideal fuels	-Grasp exhaust emissions, CO2, fine particles, etc. in the combination of vehicles and engines with future technologies and fuels, and select their optimum combination -Extract the unresolved issues through driving test with the optimum combination stated above -Find out the direction of automobile and fuel technologies aimed at “the nearest zero emissions” by resolving the issues

Outline of Oil WG Activity Plans

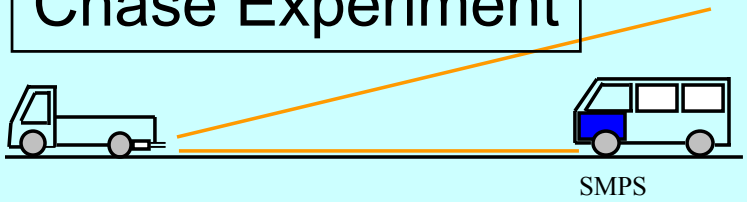
Subject	Expected results
Grasp of oil effects on after-treatment devices	-Obtain the knowledge required for oil measures by grasping effects of oil properties (Ash, P, S) on after-treatment devices (DPF, DeNox catalysts, etc.)

Outline of Unregulated Material WG Activity Plan

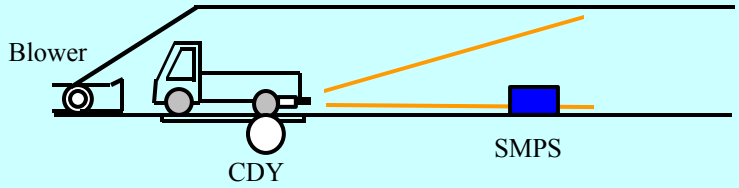
No.	Subject	Expected results
1	Study of fine particle measurement methods	-Compare and examine the measured values obtained by various measurement methods -Clarify an appropriate measurement method
2	Emission inventory measurement of fine particles	-Obtain emission inventory measured values of fine particles emitted from gasoline vehicles with the latest technologies (MPI, SIDI), and diesel vehicles (with/without DPF)
3	Compare and examine fine particle emissions in atmosphere and in laboratories	-Measure fine particles assumed to be emitted in atmosphere under various driving conditions -Grasp the relationship between fine particles emissions in atmosphere and the measured values obtained in laboratories
4	Grasp effects of fuel and lubricant properties on fine particles	-Grasp the relationship between gasoline properties and fine particles -Grasp the relationship between diesel properties and fine particles
5	Grasp the actual conditions of unregulated air pollutants	-Measure unregulated air pollutants emitted from gasoline and diesel vehicles with the latest technologies by using the most accurate measurement method at this time, and clarify the emission inventory (assumed to be quite small)

Comparison among measurement methods of fine particle emissions in atmosphere and in laboratories

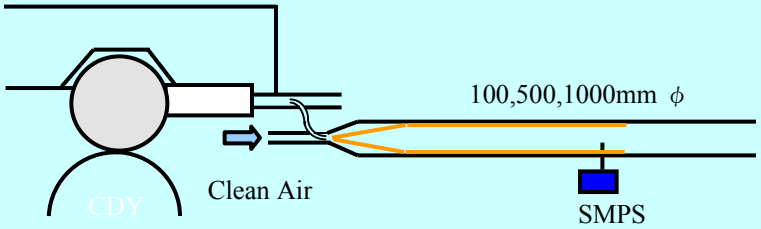
Chase Experiment



Simple Frame wind tunnel

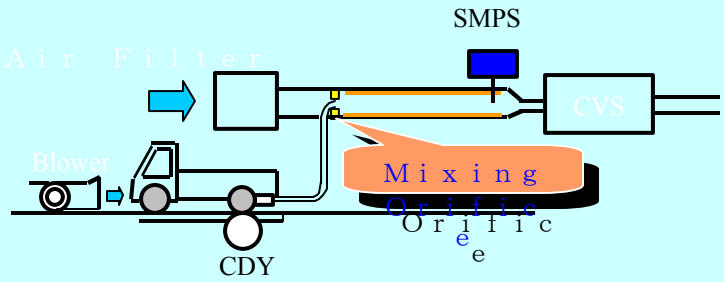


Mini Wind Tunnel



What is different?

Full Dilution Tunnel

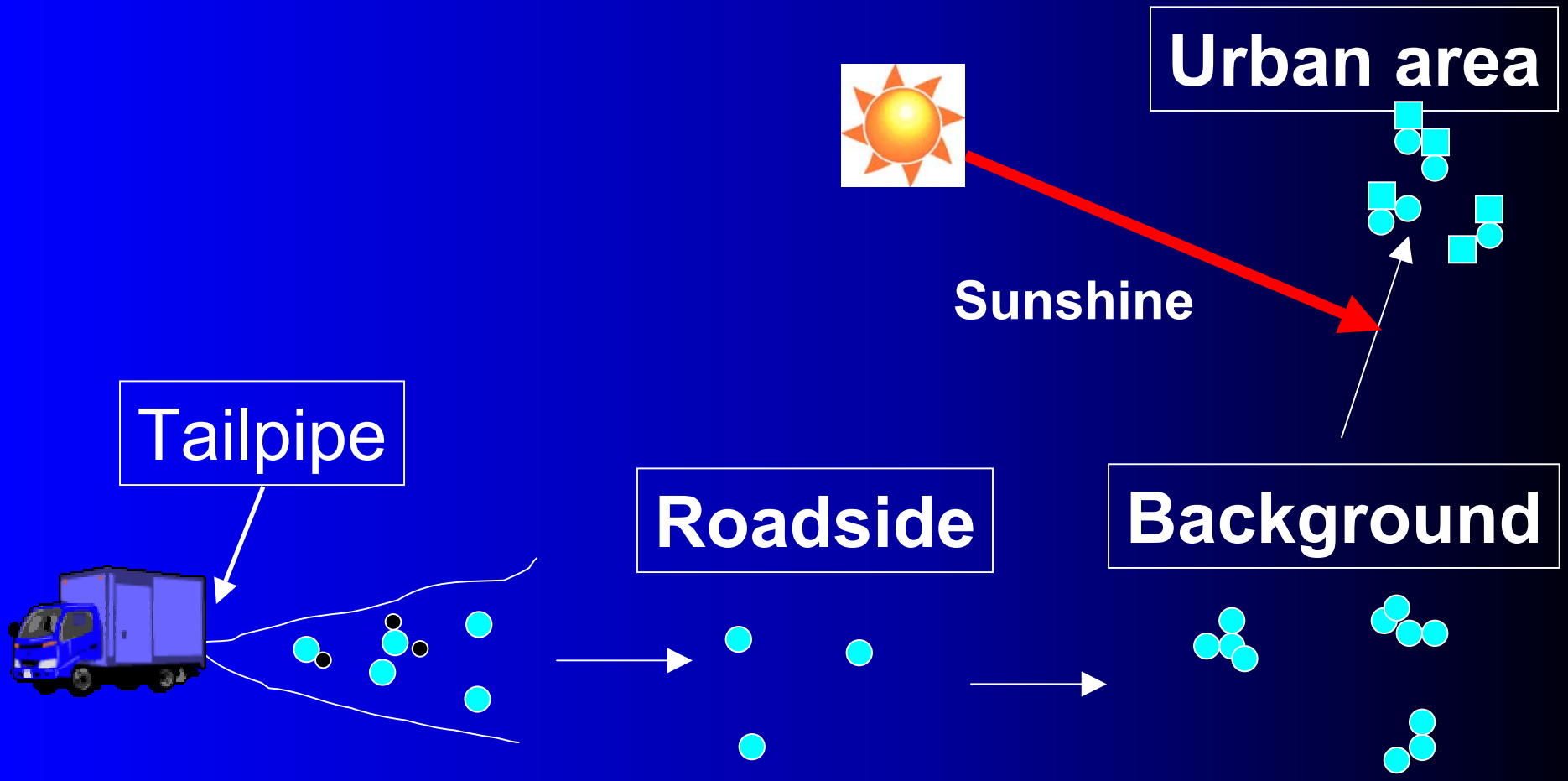


Long transfer line
Forced mixing
Lower dilution ratio

Outline of Air Quality Modeling Study

	Subject	Expected results
1	Development of next generation traffic flow modeling	-Gather data of the latest actual driving conditions such as vehicle types formation, acceleration and deceleration speed, average vehicle speed, etc. of vehicles on roads within the target area for estimating exhaust emissions from automobiles with high accuracy, establish database of them, and develop the next generation traffic flow model that reproduces the actual conditions.
2	Development of high-accurate automobile emission model	-Gather the basic emission data of the newest and old type vehicles for estimation of emissions under actual driving conditions with high accuracy, establish database of them, and develop the next generation automobile emission models
3	Development of next generation emission inventory estimation model	-Develop the next generation emission inventory estimation models that estimate the emission inventory of the target areas, based on the latest emission data of automobiles and sources other than automobiles
4	Development of high-accurate roadside air quality prediction model	-Develop a high-accurate roadside model enabling to predict automobile emissions including fine particles at the outlet of tail pipe, on the roads, around the roads, and their hinterlands, which may also predict generation/diffusion of aerosols
5	Development of next generation air quality model with high-accurate variable scale	-Introduce the latest air quality model enabling to vary the scale freely from super wide area to roadside for predicting pollutant concentration from wide-area to roadside air quality with high accuracy, and develop for applying the model to Japan
6	Development of an integrated air quality model aimed at the de facto model in Japan	-Integrate the next air quality models, and develop an integrated system enabling to set the target area flexibly, assumed the use in various organizations, develop an air quality model aimed at de facto air quality model related to automobile emissions in Japan
7	Observation of the atmosphere	-Observe the atmosphere such as long-term continuing observation of fine particles at road sides and general air quality in urban area for gathering basic data for models to be developed and verifying the models

Change of Secondary Aerosol at Roadside

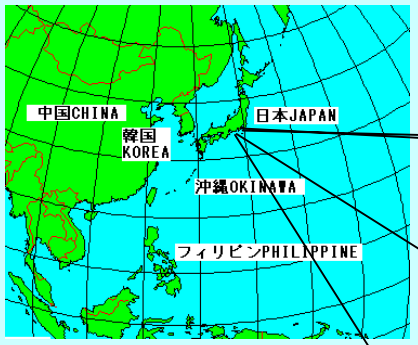


Nano-Particle change size distribution & Chemical composition.
(Vaporization, Nucleation, Condensation……)

Schematic Diagram of air quality simulation study

Metheorological model

RAMS



Regional scale model

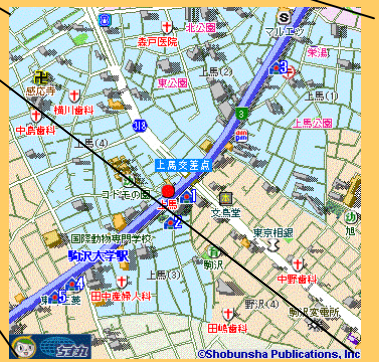
CMAQ

Urban scale model

URM

Roadside Air Flow model

RAMS



Road side model

Secondary organic aerosol formation

Nano-particle model

Condensation

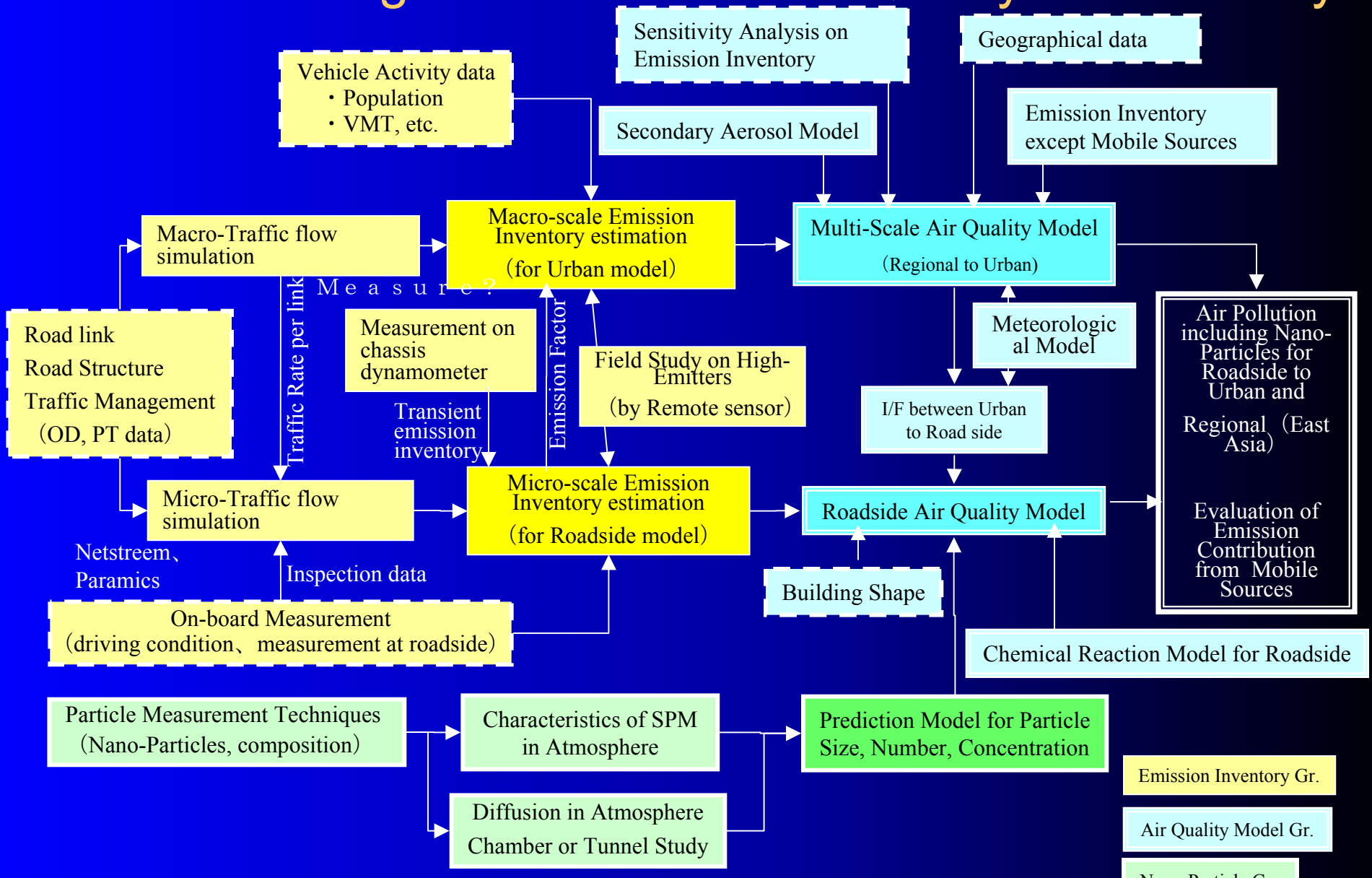
Coagulation

Nucleation

Deposition

JCAP

Schematic Diagram of JCAP II Air Quality Model Study



Japan Clean Air Program

Milestones in JCAP II Activity Plan