lab-seminar

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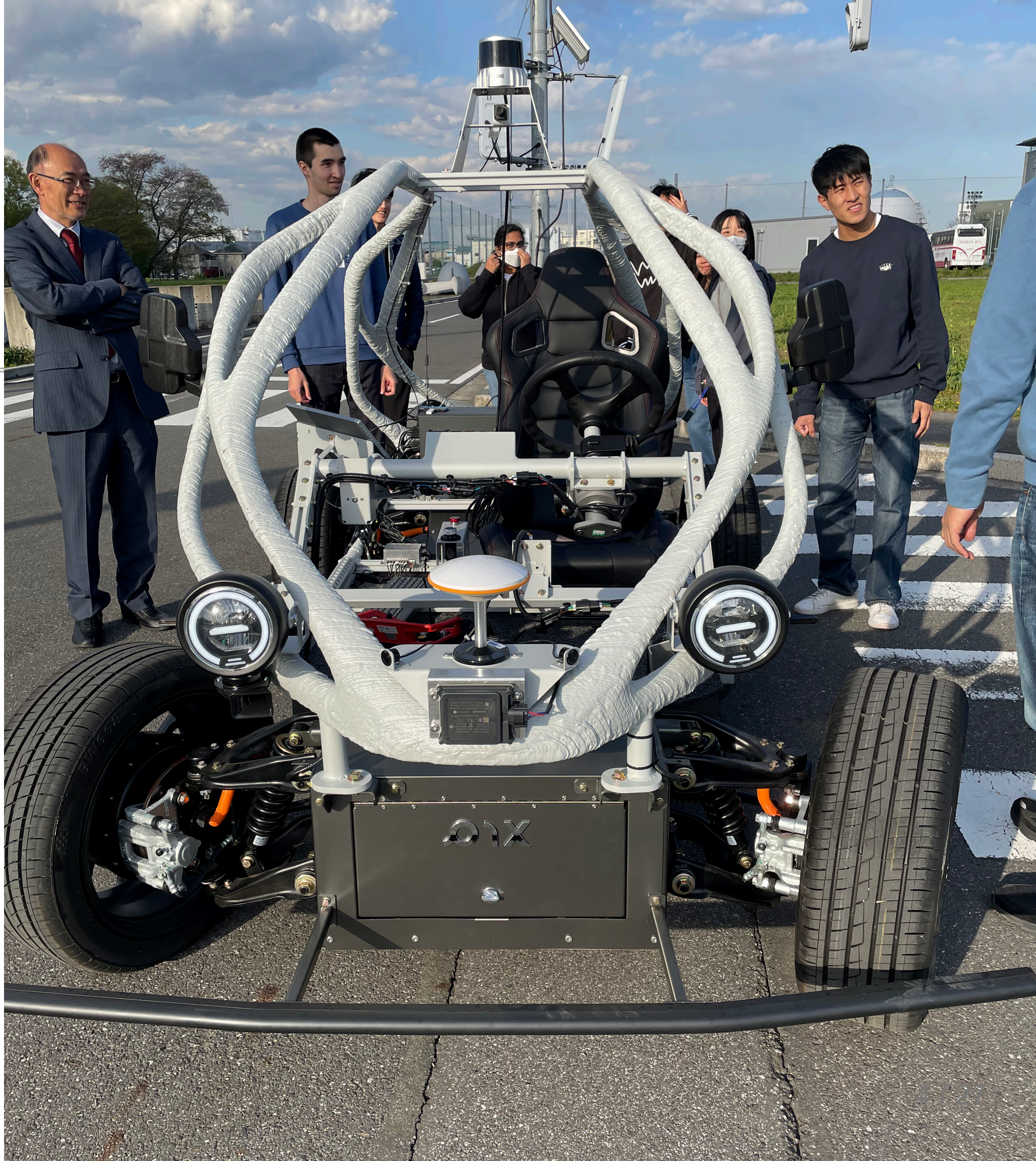
Structure

1. Background of the research
2. Previous Research
3. My Research
4. Future Work / Discussion

1. Background

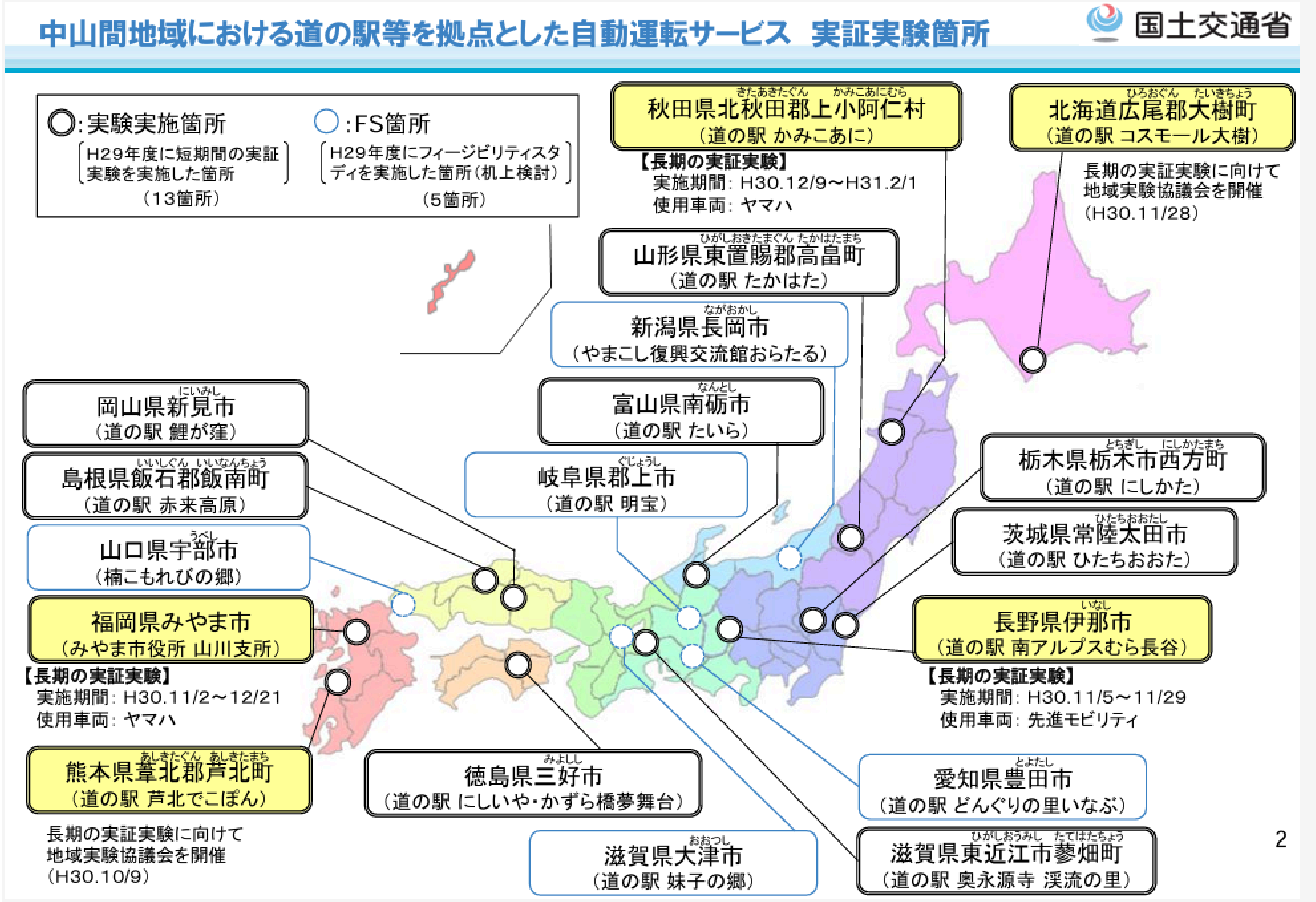
Advancement of Autonomous Driving Technology

- The development of autonomous driving technology is progressing
    - Including concepts like vehicle-to-infrastructure (V2I) communication
    - Emergence of Tesla and Waymo



Social Implementation Is a Major Challenge

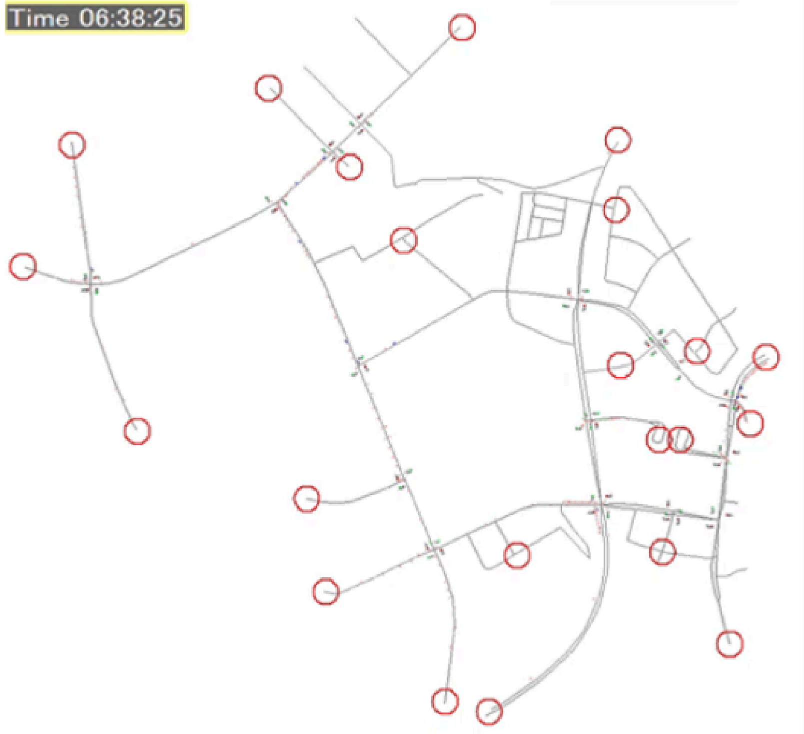
- Demonstration experiments are being conducted nationwide
  - There is a need for research that clarifies the social impacts of autonomous vehicles and helps formulate necessary policies.



Review of Previous Research

Evaluation of Traffic Impact by Autonomous Shuttle Bus in Kashiwanoha

- Evaluation of the impact on traffic flow around Kashiwanoha Campus
- level 4 autonomous shuttle bus between Kashiwanoha and Kashiwa Campus



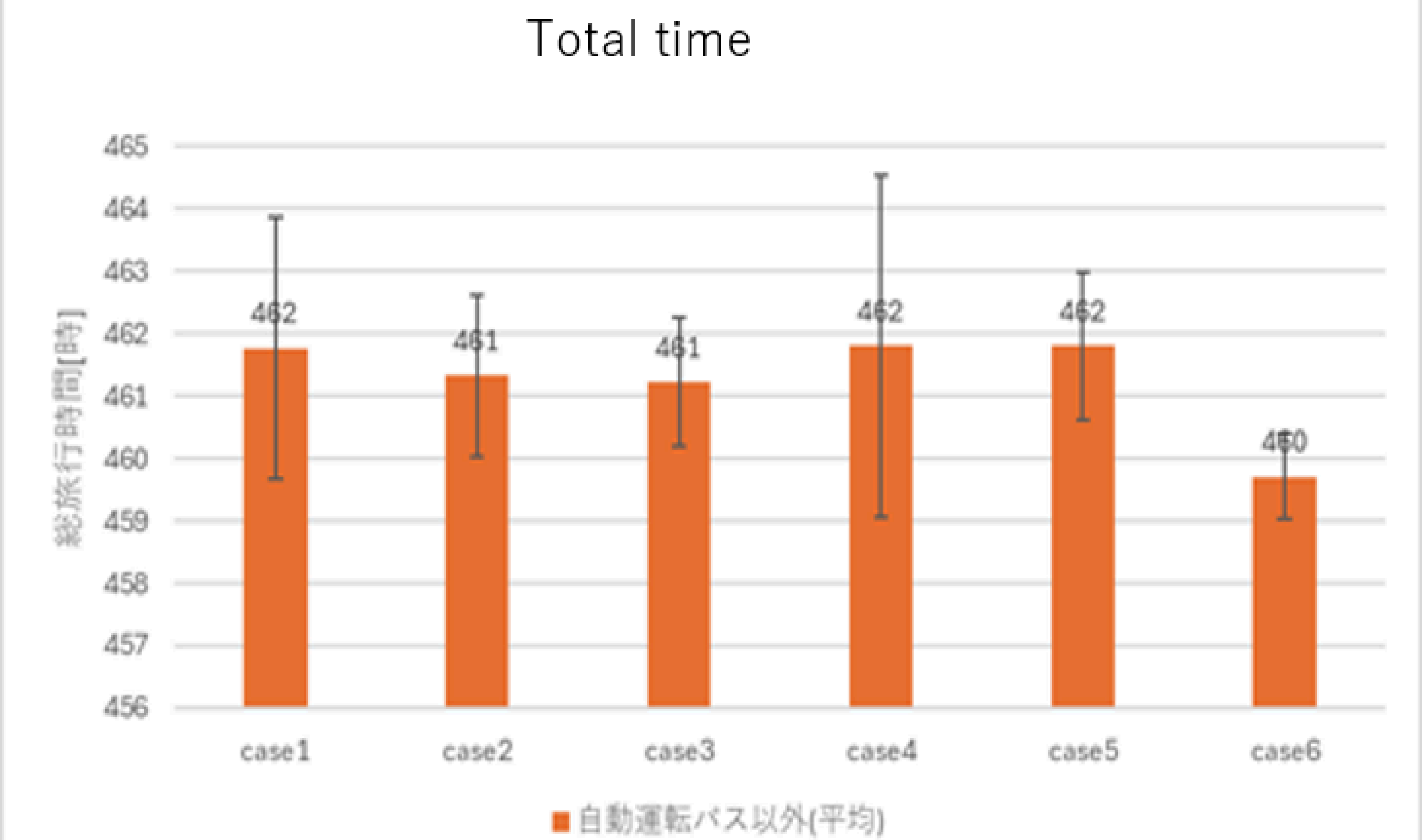
Scenarios

- Simulation conducted for six scenarios:
  - No autonomous vehicle, no policy(Case1)
  - With autonomous vehicle, no policy(Case2)
  - With autonomous vehicle, with policy(Case3-6)

senario	Data set			
senario0	Case1:no AVs			
senario1 (no policy)	Case2:with AVs			
senario2 (with policy)	Case3:policy①	Case4:policy②	Case5:policy③	Case6:policy④

Results & Consideration

- No significant impact was observed in any case
- Probably because it was only one vehicle
- Need to simulate with increased vehicle numbers



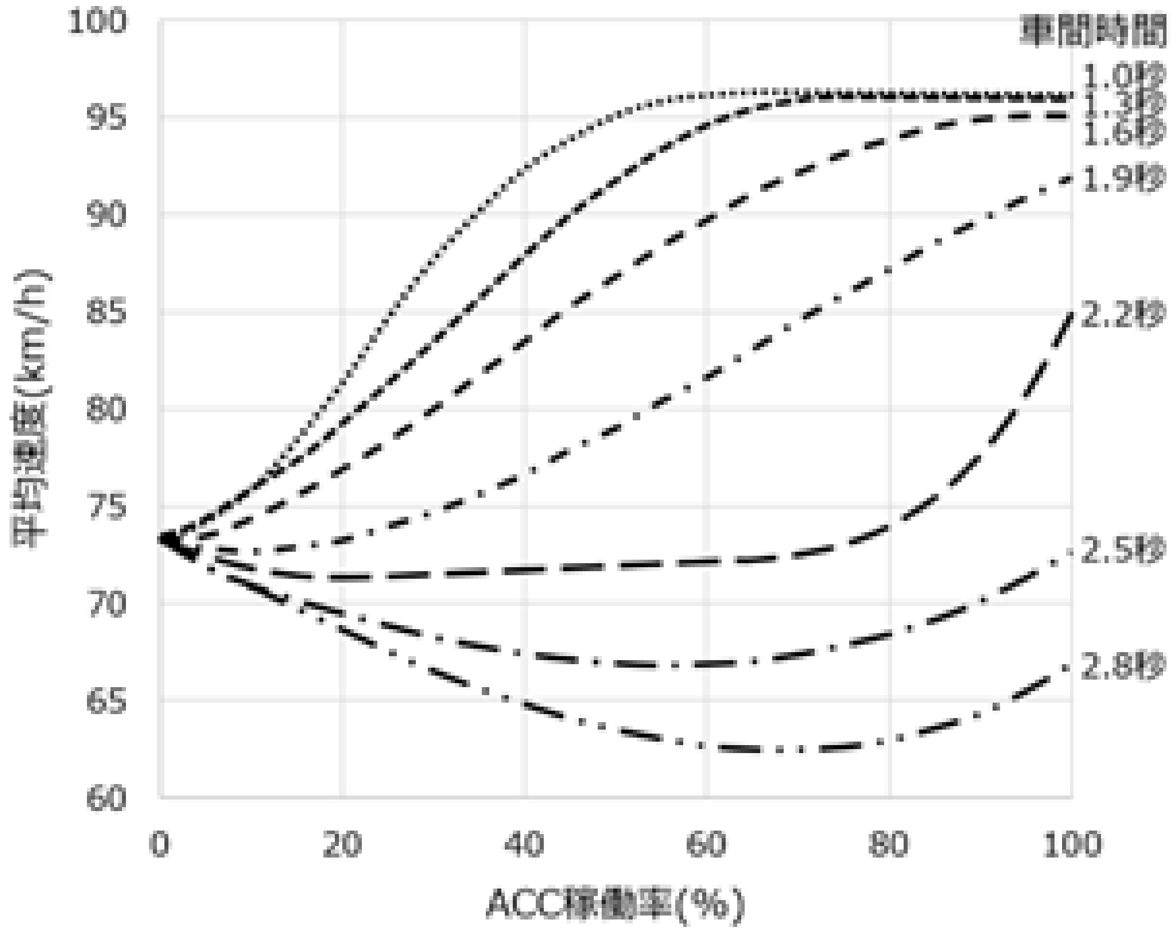
Paper on ACC (Adaptive Cruise Control)

two simulators: traffic flow & energy consumption

- I. How do ACC penetration rate and following distance settings affect traffic flow?
- II. For gasoline vehicles, how do the above conditions affect fuel consumption?
- III. For EVs, how do the above conditions affect energy consumption?

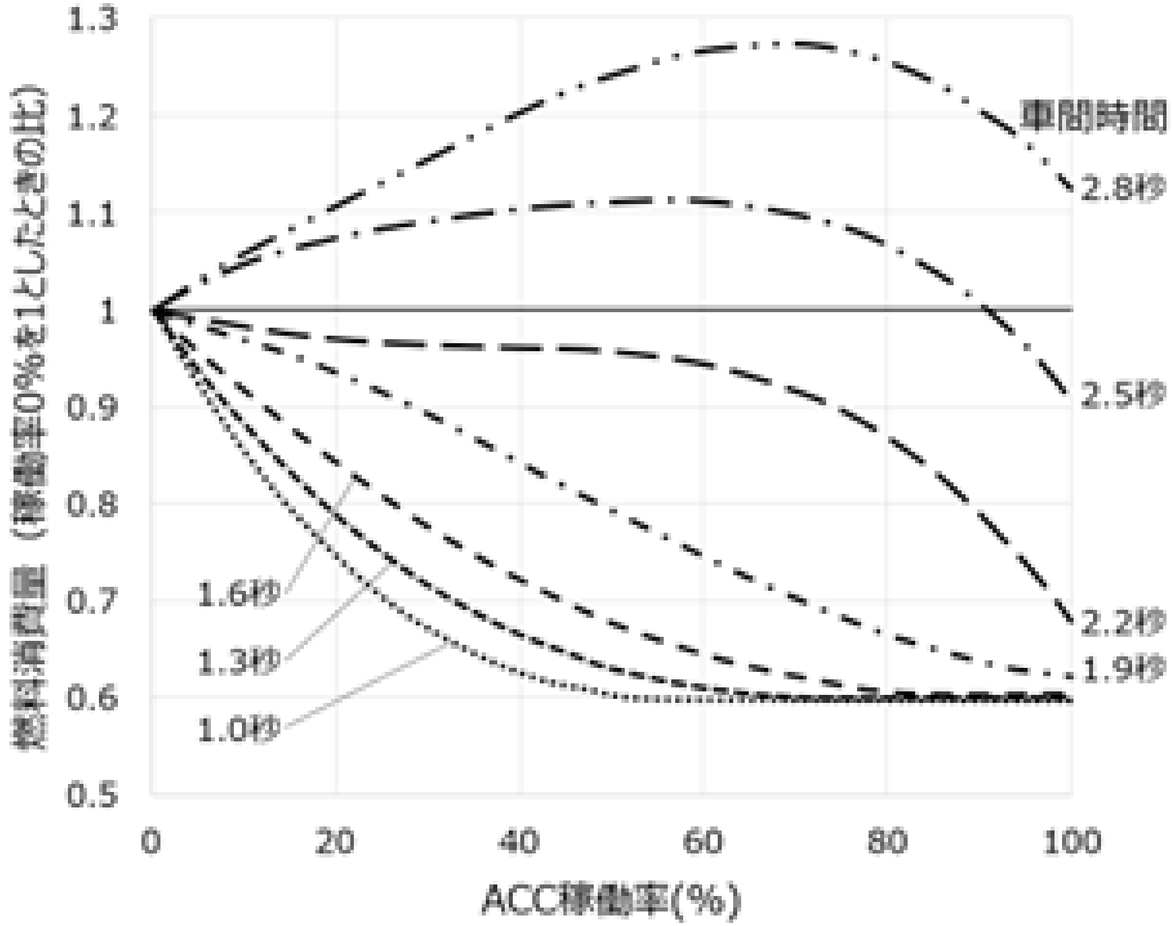
Results

- For each combination of following distance (traffic volume) and ACC penetration (autonomous ratio), congestion outcomes



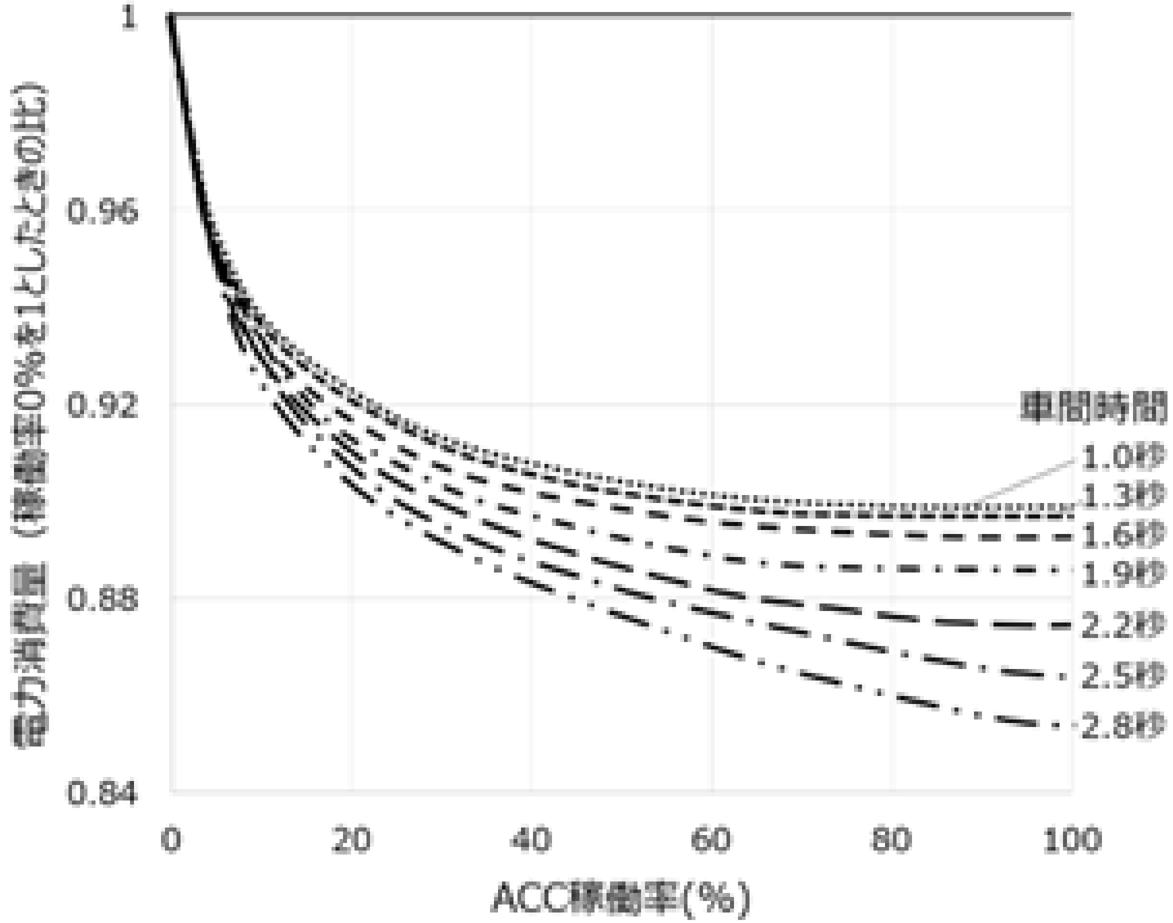
Results

- Fuel consumption for gasoline vehicles
- Higher speeds result in better fuel efficiency



Results

- Impact for EVs
  - Larger following distances lead to better energy efficiency
  - Due to dependence on acceleration



Consideration

- For fuel consumption:
  - Gasoline vehicles are more affected by speed
  - EVs are more affected by acceleration
- For gasoline vehicles, sometimes lower ACC penetration is better depending on following distance, but for EVs, higher ACC penetration is always better
- Could be applicable to autonomous driving technology as well?

2. My Research

Therefore, in this study:

Overview and Scheme

- Using the same Kashiwanoha network as the one-vehicle case, simulate with increased number of autonomous vehicles
- Two simulation targets: traffic flow and fuel consumption (gasoline & EV)

What Needs to Be Analyzed

- Traffic Flow:
  - How does autonomous vehicle affect traffic flow?
  - How does the speed of autonomous vehicles affect traffic flow?
    - Considering safe design
  - How effective are infrastructure measures?
- Fuel Consumption:
  - What is energy consumption when all vehicles are gasoline?
  - What is energy consumption when all vehicles are EVs?
  - How do infrastructure measures impact energy consumption?

Hypotheses

- Traffic Flow:
  - Traffic flow may worsen with the introduction of autonomous vehicles
- Fuel Consumption:
  - In mixed traffic of human-driven and autonomous vehicles:
    - Lower speeds increase gasoline consumption
    - For EVs, fuel efficiency may improve with higher autonomous vehicle penetration

Scenario

- The scenarios are as follows
  Infrastructure policy:
  Add dedicated parking/stopping spaces to reduce parking impact.
- No.1 & No.2:
  Scenarios without AVs, with or without infrastructure policy.
- No.4 to No.8:
  All buses are replaced by AVs. Different scenarios tested with low or very low speeds for safety.
- No.9 to No.14:
  Simulations with X% of private cars replaced by AVs.

<table>
<tr><th>No.</th><th>AV</th><th>velosity</th><th>policy</th></tr>
<tr><td>1</td><td rowspan="2">-</td><td rowspan="2">-</td><td>-</td></tr>
<tr><td>2</td><td>○</td></tr>
<tr><td>3</td><td rowspan="6">All buses</td><td rowspan="2">-</td><td>-</td></tr>
<tr><td>4</td><td>○</td></tr>
<tr><td>5</td><td rowspan="2">slow</td><td>-</td></tr>
<tr><td>6</td><td>○</td></tr>
<tr><td>7</td><td rowspan="2">Very slow</td><td>-</td></tr>
<tr><td>8</td><td>○</td></tr>
<tr><td>9</td><td rowspan="6">X% of MVs</td><td rowspan="2">-</td><td>-</td></tr>
<tr><td>10</td><td>○</td></tr>
<tr><td>11</td><td rowspan="2">slow</td><td>-</td></tr>
<tr><td>12</td><td>○</td></tr>
<tr><td>13</td><td rowspan="2">Very slow</td><td>-</td></tr>
<tr><td>14</td><td>○</td></tr>
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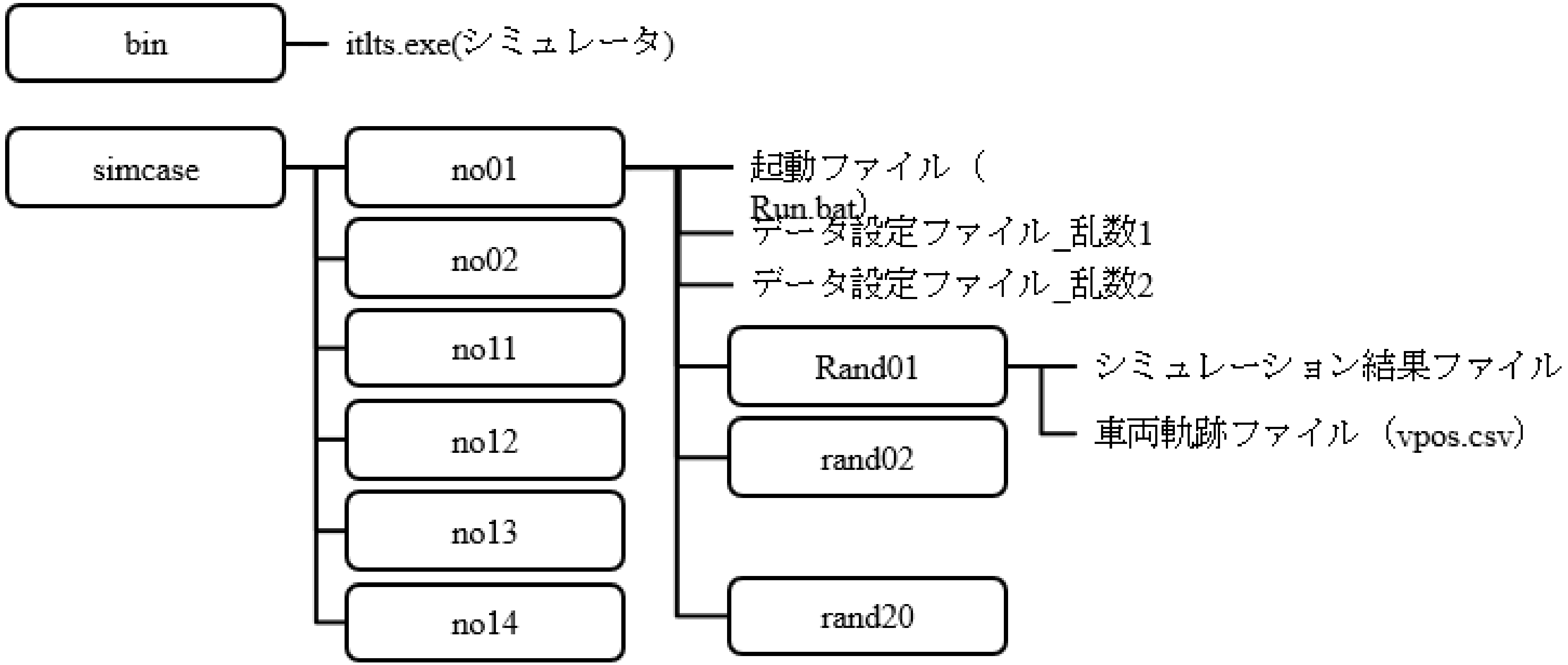
Calculation Method

- File structure



Efficiency improvement

- Want to run 20 random files in parallel for one scenario
  - The tasks to be parallelized:
    - Simulation execution
    - Data conversion (for Pioneer submission)
    - Data compression (due to large size)
    - Deletion of raw data
    - Using either batch files or Python
- Currently using batch files, but each simulation is heavy, so parallelization doesn't speed it up much

4. Future Work / Discussion

Upcoming Schedule

- This study is planned to be submitted to the autumn conference or ITS symposium
- (July) Review of previous studies
- (July–August) Simulation runs
- (August–October) Analysis
- (November or December) Presentation

Future Challenges

- There is much room for further development and discussion
  - Expand evaluation indicators, scenarios, and policies
  - Cross-city comparisons
  - Signal control
  - Pedestrian modeling
  - Network design

Appendix

シミュレーターについて

- MicroAvenueについて
- 本研究に用いた交通流シミュレータは，株式会社アイ・トランスポート・ラボ製のMicroAVENUEである(Horiguchi, 1994)．ACCの車両追従挙動を表現するために，非線形追従モデルの一種であるIntelligent Driver Model (IDM)(Treiber et al., 2000) が広く用いられている． Schakel, et al（2010）は、交通流の安定性を表現するために、IDMコントローラの改良版（IDM+）を導入した。MicroAVENUEは，追従挙動の表現にこのIDM+を用いており，縦断勾配による速度低下や渋滞のショックウェーブの状況などを表現することが可能である．シミュレーションにおけるACCが稼働している車両は，稼働していない車両と比較して，勾配による重力加速度の影響を受けない設定とした．

燃料消費量シミュレーターについて

$Pt=k1+k2\cdot|\alpha+g\cdot\sin(\theta)|\times V$
$+k3\cdot(V^3+a1\cdot V^2+a2\cdot V)$ (1)

$Pt=k1-k2\cdot\beta\cdot|\alpha+g\cdot\sin(\theta)|\times V$
$+k3\cdot(V^3+a1\cdot V^2+a2\cdot V)$ (2)

ここで，式(1)は$\alpha+g\cdot\sin(\theta)\geqq 0$の場合，式(2)は$\alpha+g\cdot\sin(\theta)<0$の場合を表す．ここで，Ptは単位時間当たりのエネルギー消費量, k1は基本消費量，k2は加減速及び傾斜による消費係数，k3は空気抵抗，転がり抵抗による消費係数，a1,a2は定数, Vは車速，αは加速度, βは回生率，θは傾斜角，gは重力加速度を示す．右辺第1項はアイドリング時のエネルギー消費量であり，速度に依存しない成分となる．右辺第2項は勾配抵抗と加速抵抗分のエネルギー消費量であり，速度変化による運動エネルギーの変化分と，高度変化による位置エネルギーの増減分である．右辺第3項は転がり抵抗成分及び空気抵抗成分によるエネルギー消費量である．