Advanced Mobility Research for Sustainable Transportation

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Outline

- Background and Sustainable transportation
- Advanced mobility research center

- ITS (Intelligent Transport System)
- Virtual Proving Ground with Driving simulator
- Advanced Automobile Research
- Self-powered Control & Electromagnetic suspension

- Modal Shift to Public Transport System
- LRT, Advanced Railway System and Eco-Ride

- Personal Mobility with Robotic Vehicle
- Experimental facilities and fields

- Concluding Remark
Energy Consumption in Japan

- Transportation: 20% of Total Energy
  - Automobile: 88% of Transportation
    - Private passenger car: 49%
    - Track for logistics: 35%
  - Railway (Passenger & Freight): only 3%

- Transport share (people x travel distance)
  - Private passenger car 60%
  - Railway and public transit: 30%
  - Efficiency 1:9
Strategy

- Innovation of automobile
  - Improve energy efficiency
- Innovation of road traffic
  - Prevent traffic congestion
  - Promote Eco-drive
- Modal shift to Railway and Public Transit
  - Motivation for public transit
    - Convenient, comfort, cost down
  - Innovation of guide way transit
  - Collaboration and innovation of Personal Mobility
Sustainable Transportation

- Low Emission & Energy Saving
- Safety & Security
- Comfort & Healthy
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Integration & Synthesis

Driver & Passenger

Road & Track

Vehicle
Establishment of Advanced Mobility Research Center

- Institute of Industrial Science established in April, 2009
- 16 Professors form Mechanical, Electrical and Civil Engineering Departments
- 51 Professors for collaborative member in Japanese Universities
- 20 members form Government and Industry
ITS (Intelligent Transport System)
Advanced Road Traffic System

Safety  Traffic efficiency  Comfort(convenience)
Solve Environment  Creating new industries/business
Main Activity for ITS Research on Our Center

- Development of Virtual Experimental Transport Experimental Space
  - Driving simulator + Traffic simulation
  - Evaluation of research output for real world

- Energy ITS project

- Eco-drive and Safety project

- Traffic management
Concept of Virtual Proving Ground Using Driving Simulator
Development of ITS Mixed Realty Transportation Experimental Space
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Traffic Simulation  Real time connection  Driving Simulator

Collaboration with 8 Companies, 5 Ministries
NEDO Energy ITS Project
Autonomous Driving System

Safety, Driverless

Eco mobility

- Eco evaluation
- Adaptation for mixed traffic with human driver
- Effect on platoon driver and HMI
- Road Map for realization

Platoon of Heavy Truck
Highway

Small Truck

Urban traffic

USA and EU has/had Platoon projects

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Experiments

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Effects on Eco Ability and Final Goal

Numerical Simulation for aero drag

Final Goal:
• Vehicle distance: 4m
• Four trucks with different size
• Speed: 80 km/h
• At least 15% reduction of energy consumption
R&D for Electrical Drive for Automobile

- Plug-in Hybrid Vehicle
- EV

This type of Development is mainly made by Company
R&D for electromagnetic device for suspension

- Passive Damper
- Motion control theory by electromagnetic device
- Actuator
- Energy Regeneration
- Sensor
- Spring

Apply to various systems with adjust for individual feature

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Practical Research with Industries

- Passenger car:
  - Improvement of ride comfort
  - Energy regeneration from vibration
  - Quick response and control of road folding
- Heavy duty truck:
  - Vehicle stability and prevent turn over
  - Improvement of drivability

- Original device developed by laboratory
- Collaborative Study with KAYABA, TOYOTA and HINO
Self-Powered Active Control

Control Performance

Self-Powered Control

Active Suspension System

Passive Suspension System

Passive Suspension with Energy Regenerative Damper System

Energy Regeneration

Energy Consumption

No External Energy but High Performance

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Application to High Speed Rail Vehicle

Full-active Control

Energy consumption of active control can be reduced significantly by utilizing regenerated energy effectively.

Collaboration with East Japan Railway

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Modal shift to high speed rail in Europe and Asia

JR Central, Japan  
JR East, Japan  
German ICE  
French TGV  
Taiwan High Speed  
Chinese High Speed

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Modal Shift to LRT (Light Rail Transit) in Europe

France Paris

Germany Munich

Hungary Budapest

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LRT (Light Rail Transit) for Public Transit in Japan

Kumamoto

Hiroshima

Takaoka

Toyama
Key Words for LRT
Light Rail Transit

Improvement of Performance

- Self-steering
  - Tight curve negotiation ability in urban area
  - Independent rotating wheel for low floor

- Self-power
  - Hybrid system with battery
  - Without trolley for city amenity
  - Energy regeneration
Developed vehicles with Self-steering truck and battery

1/10 Scaled Model Vehicle with proposed self-steering independent rotating wheel in Chiba Experiment Station

Low floor vehicle with battery powered traction by Kawasaki Heavy Industries

Asymmetric design with independent rotating wheel

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Development of Energy Saving Urban Transportation System "Eco-Ride"

- Full scale Experimental vehicle and test track at Chiba Experiment Station, Institute of Industrial Science, The University of Tokyo
- Collaboration with Senyo Kogyo supported NEDO and METI
Concept and property

- Potential Energy
- Roller Costar Technology

- Short distance less than 10 km
- Transport capacity 2000-2500 persons/hour
- Max Speed 40 km
Main Characteristics

- Light weight vehicle without power unit
- Safety by existing roller costar technology
- Low cost for construction
Energy Consumption and Cost for Construction

Energy consumption:
- 1/10 of automobile
- Half of railway

Construction Cost:
- 1/10 of mini subway
- Same as LRT
Personal Mobility Vehicle with Robot Technology

- Short distance transport with electric drive and/or human power
- Safety operation in pedestrian area
- Compact and light weight for carry by public transit and car
Present Personal Vehicle

- Bicycle (Series two wheel vehicle)
- Electric Powered Assist Bicycle
- Parallel two wheel vehicle (Segway)

Too large and heavy for Japanese
Out of regulation for public road

Unstable at low speed
Collaboration with TOYOTA for developing Personal Mobility Vehicle

Experiment for safety and comfort for pedestrian area
Proposed Hybrid PMV
Personal Mobility Vehicle

Bicycle mode
Reverse Pendulum mode

High Speed
Long Distance
Low Speed
Short Distance Indoor

Steer by wire, Light weight, Compact

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Proposed New Concept Robotic Vehicle

- Stability control by electric motor
- Human pedaling and electric power assist

Merits:
- Low energy consumption
- Healthy
- Long distance operation
Trial Vehicle for Experiments of Steering and Traction

Encoder for pedaling

Reaction force actuator

Gyro sensor
Field Experiments at Chiba Experiment Station, IIS, The University of Tokyo

Full Scale LRT Test Track
Eco-ride Test Track
ITS Test Road
Probing Ground
Universal Driving Simulator
Important Integrations

- Research Fields
  - Mechanical and Vehicle
  - Electric and Electronics
  - Civil and Transportation
  - Information Science and Technology

- Sectors
  - Industry
  - Academia
  - Government (Local and Federal)
  - Citizen

- Modal mix
  - Road and Automobile (ITS)
  - Public Transit (LRT, Subway, High Speed Rail)
  - New Concept Personal mobility with robot technology
Key Words for Sustainable Transport

- ITS for road traffic and advanced automobile
  - Improvement of Energy efficiency of automobile
  - Intelligent management of Traffic, Energy flow

- Advanced Guideway System
  - Modal shift from automobile to public transit system
  - LRT and new concept system “Eco-ride” in urban area
  - Energy efficiency High-speed rail and Maglev

- Personal Mobility
  - Promote to small EV and human power
  - Promote from automobile to public transit
  - Robotic two wheel vehicle for stability and safety
Concluding Remarks

- Advanced Mobility Research Center Conducts for Sustainable Transportation
- Synthesis and Integration
  - Integration of Technology area
  - University - Industry - Government
  - Automobile + Public Transit + Personal Mobility
- Improvement of Energy efficiency
- Field Experiments and Evaluation