University Transportation Research Center - Region 2

Final Report

Energy, Ride Comfort and Road Handling of Regenerative Vehicle Suspensions

Performing Organization: Stony Brook, State University of New York

February 2014

Sponsor:
University Transportation Research Center - Region 2

University Transportation Research Center - Region 2

The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

Research

The research program objectives are (1) to develop a theme based transportation research program that is responsive to the needs of regional transportation organizations and stakeholders, and (2) to conduct that program in cooperation with the partners. The program includes both studies that are identified with research partners of projects targeted to the theme, and targeted, short-term projects. The program develops competitive proposals, which are evaluated to insure the mostresponsive UTRC team conducts the work. The research program is responsive to the UTRC theme: "Planning and Managing Regional Transportation Systems in a Changing World." The complex transportation system of transit and infrastructure, and the rapidly changing environment impacts the nation's largest city and metropolitan area. The New York/New Jersey Metropolitan has over 19 million people, 600,000 businesses and 9 million workers. The Region's intermodal and multimodal systems must serve all customers and stakeholders within the region and globally.Under the current grant, the new research projects and the ongoing research projects concentrate the program efforts on the categories of Transportation Systems Performance and Information Infrastructure to provide needed services to the New Jersey Department of Transportation, New York City Department of Transportation, New York Metropolitan Transportation Council , New York State Department of Transportation, and the New York State Energy and Research Development Authorityand others, all while enhancing the center's theme.

Education and Workforce Development

The modern professional must combine the technical skills of engineering and planning with knowledge of economics, environmental science, management, finance, and law as well as negotiation skills, psychology and sociology. And, she/he must be computer literate, wired to the web, and knowledgeable about advances in information technology. UTRC's education and training efforts provide a multidisciplinary program of course work and experiential learning to train students and provide advanced training or retraining of practitioners to plan and manage regional transportation systems. UTRC must meet the need to educate the undergraduate and graduate student with a foundation of transportation fundamentals that allows for solving complex problems in a world much more dynamic than even a decade ago. Simultaneously, the demand for continuing education is growing – either because of professional license requirements or because the workplace demands it – and provides the opportunity to combine State of Practice education with tailored ways of delivering content.

Technology Transfer

UTRC's Technology Transfer Program goes beyond what might be considered "traditional" technology transfer activities. Its main objectives are (1) to increase the awareness and level of information concerning transportation issues facing Region 2; (2) to improve the knowledge base and approach to problem solving of the region's transportation workforce, from those operating the systems to those at the most senior level of managing the system; and by doing so, to improve the overall professional capability of the transportation workforce; (3) to stimulate discussion and debate concerning the integration of new technologies into our culture, our work and our transportation systems; (4) to provide the more traditional but extremely important job of disseminating research and project reports, studies, analysis and use of tools to the education, research and practicing community both nationally and internationally; and (5) to provide unbiased information and testimony to decision-makers concerning regional transportation issues consistent with the UTRC theme.

UTRC-RF Project No: 49111-13-23

Project Date: February 2014

Project Title: Energy, Ride Comfort and Road Handling of Regenerative Vehicle Suspensions

Project's Website:
http://www.utrc2.org/research/projects/regenerative-vehicle-suspensions

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Performing Organization: State University of New York at Stony Brook

Sponsor:

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Nathalie Martinez: *Research Associate/Budget Analyst*

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15. Supplementary Notes

16. Abstract

In this project we report a comprehensive assessment of the power that is available for harvesting in the vehicle suspension system and the tradeoff among energy harvesting, ride comfort, and road handing with analysis, simulations, and experiments. The excitation from road irregularity is modeled as a stationary random process with road roughness suggested in the ISO standard. The concept of system H2 norm is used to obtain the mean value of power generation and the root mean square values of vehicle body acceleration (ride quality) and dynamic tire-ground contact force (road handling). For a quarter car model, an analytical solution of the mean power is obtained. The influence of road roughness, vehicle speed, suspension stiffness, shock absorber damping, tire stiffness, and the wheel and chasses masses to the vehicle performances and harvestable power are studied. Experiments are carried out to verify the theoretical analysis. The results suggest that road rough-ness, tire stiffness, and vehicle driving speed have great influence on the harvesting power potential, where the suspension stiffness, absorber damping, and vehicle masses are insensitive. At 60 mph on good and average roads, 100–400 W average power is available in the suspensions of a middle-sized passenger car. More energy harvesting potential is available for heavy-duty trucks and off-road vehicles.

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UNIVERSITY TRANSPORTATION RESEARCH CENTER

RESEARCH BRIEF

PROJECT TITLE: ENERGY, RIDE COMFORT AND ROAD HANDLING OF REGENERATIVE VEHICLE SUSPENSIONS

PRINCIPAL INVESTIGATOR(S): DR. LEI ZUO

INSTITUTION: STATE UNIVERSITY OF NEW YORK AT STONY BROOK

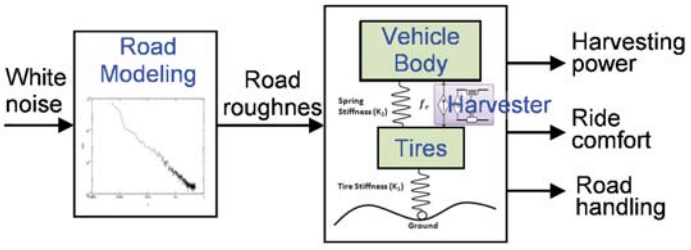
COMPLETION DATE: JULY 31, 2013

SPONSOR: UNIVERSITY TRANSPORTATION RESEARCH CENTER (UTRC)

In this project we report a comprehensive assessment of the power that is available for harvesting in the vehicle suspension system and the tradeoff among energy harvesting, ride comfort, and road handing with analysis, simulations, and experiments. The excitation from road irregularity is modeled as a stationary random process with road roughness suggested in the ISO standard. The concept of system H2 norm is used to obtain the mean value of power generation and the root mean square values of vehicle body acceleration (ride quality) and dynamic tire-ground contact force (road handling). For a quarter car model, an analytical solution of the mean power is obtained. The influence of road roughness, vehicle speed, suspension stiffness, shock absorber damping, tire stiffness, and the wheel and chasses masses to the vehicle performances and harvestable power are studied. Experiments are carried out to verify the theoretical analysis. The results suggest that road rough-ness, tire stiffness, and vehicle driving speed have great influence on the harvesting power potential, where the suspension stiffness, absorber damping, and vehicle masses are insensitive. At 60 mph on good and average roads, 100–400 W average power is available in the suspensions of a middle-sized passenger car. More energy harvesting potential is available for heavy-duty trucks and off-road vehicles.

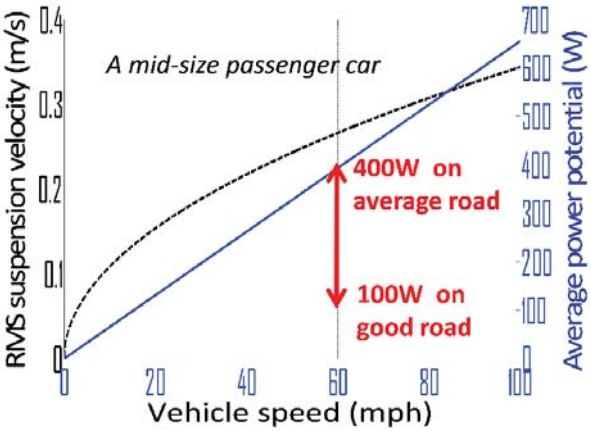
Journal publication resulted from this UTRC-II minigrant:

L. Zuo and P. Zhang, "Energy Harvesting, Ride Comfort, and Road Handling of Regenerative Vehicle Suspensions", ASME Journal of Vibration and Acoustics, Vol 135, 2013.

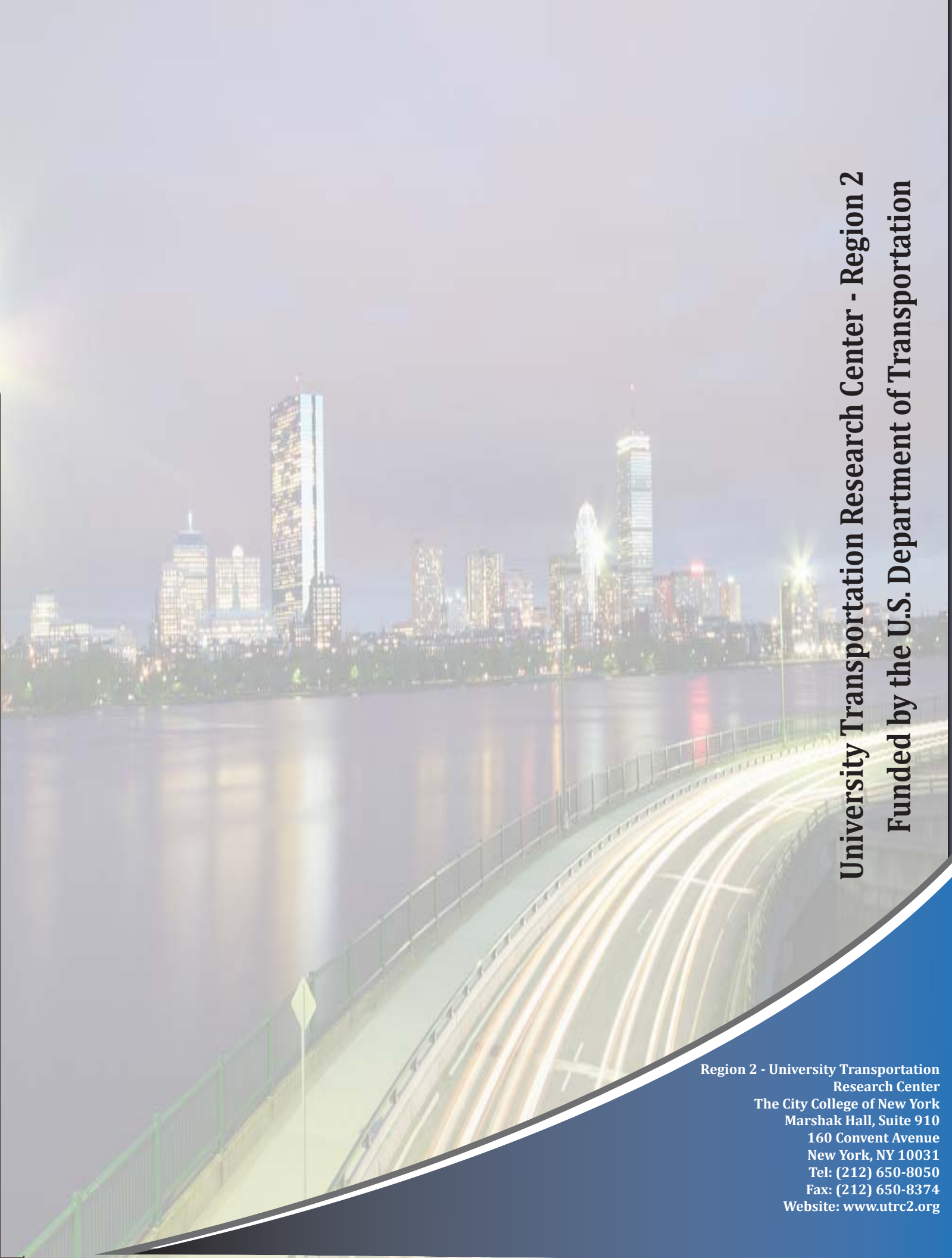


Modelling of the overall road-vehicle dynamics

Experiment setup: road test using a super compact vehicle



Suspension velocity and harvesting power potential in a typical passenger car at various vehicle speeds



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