Smart Cruise Control: an ITS Application for Improved Fuel Economy, Safety, and Traffic Flow

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Some of the greatest challenges in transportation today are associated with reducing fuel consumption and vehicle emissions, improving safety on the roadway, and in increasing the efficiency of use of the highway infrastructure, which is becoming increasingly congested. These problems are the root of the current objectives to reduce our nation's dependency on fossil fuels, reduce greenhouse gas emissions and improve the nation's transportation infrastructure, thereby improving our security and developing a sustainable energy and transportation future. Reducing the amount of braking done by a vehicle, by anticipating what is ahead and adjusting speed more gradually before arriving at the site where braking would be required, results in improvements in both fuel economy and safety. More stable speeds on the roadway with reduced areas of stopped traffic also improve the throughput of traffic over a given region. To address these issues, it is proposed to develop a new "Smart" Cruise Control system that would incorporate the following:

- GPS positioning and route planning to identify elevation variations and curves in the road ahead.
- Vehicle-to-vehicle (V2V) communications to provide information of traffic conditions ahead with a real-time communication network that can also transmit data to ground-based traffic management systems.
- On-vehicle trajectory modeling with an optimization routine that calculates an alternative speed profile in which braking is minimized.

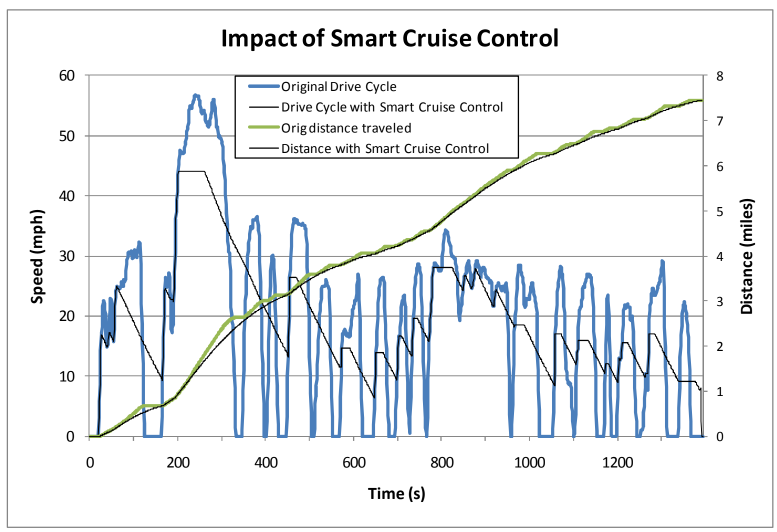

Figure 1: A fully optimized drive cycle with Smart Cruise Control includes no braking, but the original and optimized cycles have the same arrival time.

Center for Transportation Analysis
Oak Ridge National Laboratory
2360 Cherahala Boulevard
Knoxville, TN 37932
865.946.1349
(Fax) 865.946.1314

Website: cta.ornl.gov

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- Active control of the speed of the vehicle so that it will not be excessive relative to (i) the speed limit, (ii) a safe speed while the vehicle traverses a curve along its route (based on a maximum acceptable lateral acceleration), or (iii) slowed traffic.

The element of estimating the vehicle's speed at a later point in time and allowing the vehicle to decelerate slowly, by coasting, at the vehicle's current location can significantly reduce the need to apply the brakes over the route. The trajectory model can be accomplished with a simple physics-based analysis accounting for all energy losses from the vehicle—including friction within the vehicle drivetrain, tire rolling resistance and aerodynamic drag—in a manner similar to how vehicle fuel economy is simulated today, even if the model will be greatly simplified.

Such a system can be developed almost entirely by integrating existing technologies, and the fuel economy and safety benefits during off-highway travel can be significant. This system can be retrofitted to the current vehicle fleet, which would allow the improvements to take effect much more quickly than what could be achieved with systems that require substantial infrastructure changes or that could not be implemented through an upgrade or retrofit. The system is also applicable to both passenger and commercial vehicles. Furthermore, additional functionality can be added to the system with newer vehicles and improved infrastructure that can compound the improvements in fuel economy and traffic throughput efficiency of the road system.

Fuel Economy Benefits

Initial results from fuel economy modeling are very promising. The mechanical energy input to the wheels for acceleration can be reduced by up to 70% when the drive cycle is fully optimized with the Smart Cruise Control system, yielding fuel savings over 30%. Additionally, emissions can be significantly reduced.

Model result	Original Drive Cycle	Optimized Drive Cycle
Fuel Economy (mpg)	35.4	53.0
Fuel consumed (gal)	0.21	0.14
NO_x Emissions (g)	4.7	2.3
CO Emissions (g)	9.7	7.8

Table 1: Fuel economy and emissions predictions using PSAT.

Future Efforts

The long-term vision for this project is to link this system with a ground-based system that performs traffic modeling, optimizes traffic signal timing and re-routes vehicles so that traffic throughput can be maximized. Vehicle-to-Infrastructure (V2I) communications will provide the Smart Cruise Control system with information regarding upcoming traffic signal changes, which further improves the automated look-ahead capabilities. By also integrating this system into hybrid vehicles equipped with engine stop/start technology, regenerative braking systems, and automated electronic control timing of auxiliary systems on the vehicle, the Smart Cruise Control system can further optimize fuel economy by providing real-time information to these vehicle functions, allowing truly optimal performance. Additional research is needed to quantify the benefits of the system on traffic performance and to complete the development of Smart Cruise Control and integrate it with other ITS systems.

The improvements offered by the Smart Cruise Control system will provide a tangible first step to many of the planned advancements in transportation infrastructure envisioned under the Intelligent Transportation Systems (ITS) and IntelliDrive^{SM} initiatives.[1] This technology, however, can be developed within a timeframe of only a few years and will serve as an early demonstration of the advancements planned in the future for these programs.

[1] The IntelliDrive^{SM} Logo is a service mark of the U.S. Department of Transportation

For more information regarding this research contact Tim LaClair, Center for Transportation Analysis, Oak Ridge National Laboratory, phone (865) 946-1305 or email laclairtj@ornl.gov.