

## Trip Optimizer for Railroads

On-time arrival with the least fuel expenditure is a key priority for freight (and passenger) railroads worldwide. North American railroads consumed 4 billion gallons of fuel in 2008, accounting for 26% of operating costs.

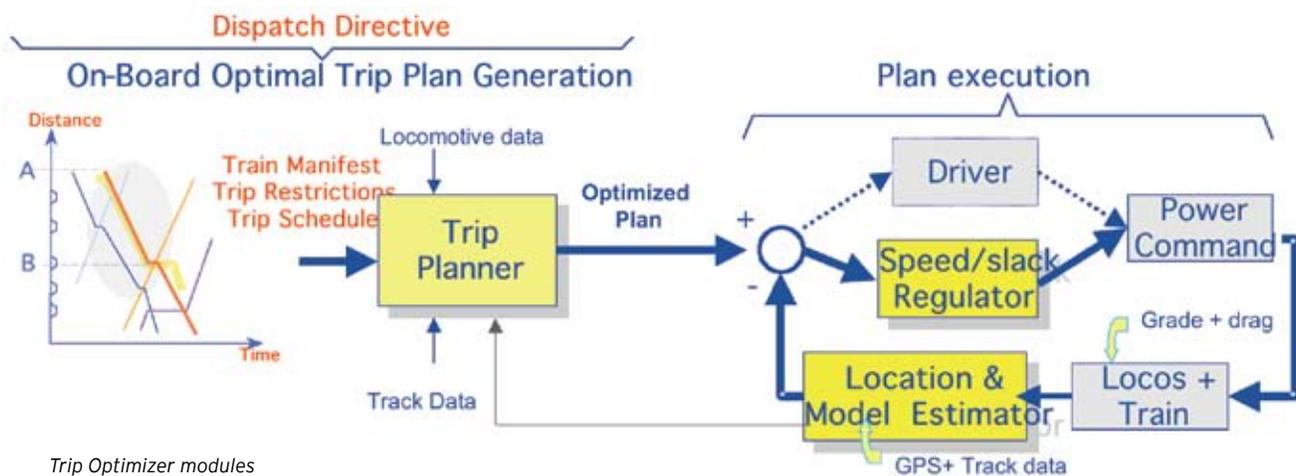
GE's Trip Optimizer is an easy-to-use control system that allows the crew or dispatcher to achieve on-time arrival with the least possible fuel use.

Optimal driving solutions are computed onboard and executed in closed loop using GPS-based navigation. Train and track parameters are adapted online to reduce model errors. Fuel savings of 3% to 17% are realized.



### Trip Optimizer Modules

- Trip Planner finds the driving strategy (speed and throttle) that minimizes fuel for the target arrival time and satisfies speed limit and other train and locomotive operating constraints.
- Speed Regulator closes the loop around the plan to correct for modeling errors and external disturbances and provides compensation for slack-action in the distributed dynamics of typical mile-long, heavy trains; both hands-off closed-loop and driver-in-the-loop "coaching" solutions are available.
- Location and Model Estimator provides precise location of the train and compensation for GPS dropouts, and adaptively tracks train parameters such as weight, length, and drag.

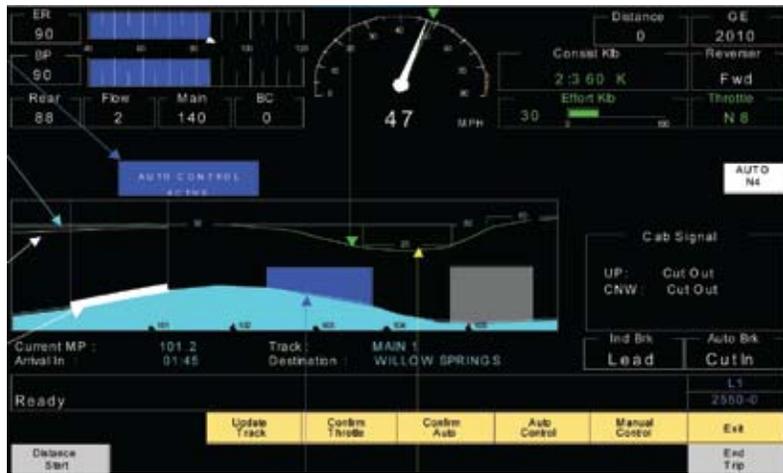


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For each Evolution locomotive on which it is used, Trip Optimizer can reduce fuel consumption by 32,000 gallons, cut CO<sub>2</sub> emissions by more than 365 tons, and cut NOx emissions by 3.7 tons per locomotive per year. If Trip Optimizer is deployed on the approximately 10,000 similar locomotives in service in North America, these savings equate to taking a million passenger cars off the road for a year.



Trip Optimizer is a product of GE Transportation, Erie, Pennsylvania.



### Inventions and Innovations

Trip Optimizer provides innovative solutions to the optimization, estimation, control, and operator interface requirements for achieving fuel savings and emissions reductions for freight railroads.

Computation of the driving plan requires solving a math program with thousands of constraints and decision variables in seconds, with time- and fuel-based objectives.

Robust speed regulator design relies on a loop-shaping algorithm to maintain stable operation and deal with variations in intercar separation and the resulting forces.

Location estimator provides precise coordinate tracking via Kalman-filter-based compensation for GPS dropouts. Model-based methods adaptively track key train parameters using GPS and other locomotive data. Tools for extensive offline analysis were also developed to produce high-integrity database sources for use in control and estimation.

Innovative displays bring intuitive mode awareness and ease of use to the underlying optimal control strategy. Experienced drivers can learn the system in minutes.

Robust satellite communication from the locomotive provides rapid access to train data (and updates) directly from railroad mainframes with backup from a dedicated 24/7 GE facility.

### More Than 5 Million Miles of Successful Revenue Service on North American Railroads

- Canadian Pacific
- Burlington Northern Sante Fe
- CSX
- Canadian National
- Total fuel savings to date of over 3 million gallons!