



Reducing Aerodynamic Drag on Empty Open Cargo Vehicles

Open cargo bays are subdivided by means of simple partitions.

Ames Research Center, Moffett Field, California

Some simple structural modifications have been demonstrated to be effective in reducing aerodynamic drag on vehicles that have empty open cargo bays. The modifications were originally intended to be made in railroad coal cars because the amounts of coal and the distances over which they are transported by railroad in the United States are so large that the resulting reduction in drag could, potentially, result in an annual saving of millions of gallons of diesel fuel.

The basic idea is to break up the airflow in a large open cargo bay by inserting panels to divide the bay into a series of smaller bays. In the case of a coal car, this involves inserting a small number (typically between two and four) of vertical full-depth or partial-depth panels. For example, as shown in Figure 1, two triangular partial-depth vertical panels can be conveniently attached to triangular braces that are already integral parts of a typical coal car.

In an experiment, measurements of aerodynamic drag on models of coal cars were made in a wind tunnel. The results of the measurements, summarized in Figure 2, clearly show the drag-reducing effects of the dividers; they also show that the braces also contribute small reductions of drag.

This work was done by James C. Ross of Ames Research Center, Bruce L. Storms of Aerospace Computing, Inc., and Dan Dzoan of Ohlone College.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-15422-1.



Figure 1. **Triangular Dividers** can be attached to triangular braces in a typical coal car to reduce aerodynamic drag when the car is empty.

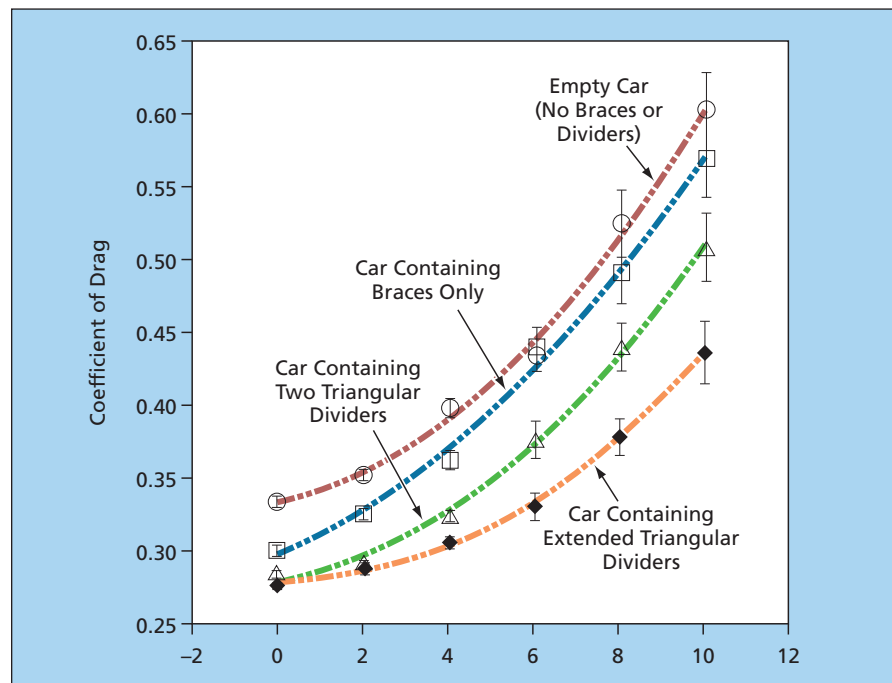


Figure 2. **Wind-Averaged Data** on the coefficient of drag were obtained in wind-tunnel tests of coal-car models like those of Figure 1. The yaw angle is the angle between the relative wind and the longitudinal axis of a car.

Rotary Percussive Auto-Gopher for Deep Drilling and Sampling

A drilling/sampling apparatus braces itself against the side of the hole.

NASA's Jet Propulsion Laboratory, Pasadena, California

The term "rotary percussive auto-gopher" denotes a proposed addition to a family of apparatuses, based on ultrasonic/sonic drill corers (USDCs), that have been described in numerous pre-

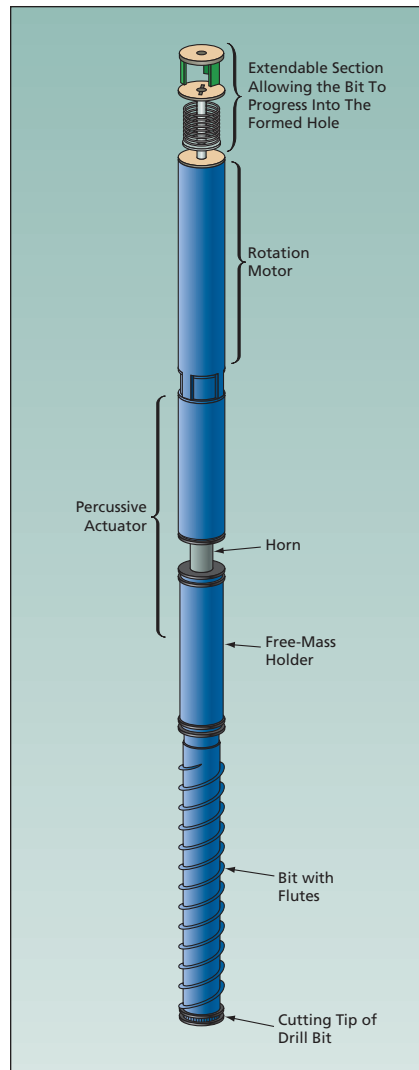
vious *NASA Tech Briefs* articles. These apparatuses have been designed, variously, for boring into, and/or acquiring samples of, rock or other hard, brittle materials of geological interest. In

the case of the rotary percussive auto-gopher, the emphasis would be on developing an apparatus capable of penetrating to, and acquiring samples at, depths that could otherwise be reached

only by use of much longer, heavier, conventional drilling-and-sampling apparatuses.

To recapitulate from the prior articles about USDCs: A USDC can be characterized as a lightweight, low-power jackhammer in which a piezoelectrically driven actuator generates ultrasonic vibrations and is coupled to a tool bit through a free mass. The bouncing of the free mass between the actuator horn and the drill bit converts the actuator ultrasonic vibrations into sonic hammering of the drill bit. The combination of ultrasonic and sonic vibrations gives rise to a hammering action (and a resulting chiseling action at the tip of the tool bit) that is more effective for drilling than is the micro-hammering action of ultrasonic vibrations alone. The hammering and chiseling actions are so effective that the size of the axial force needed to make the tool bit advance into soil, rock, or another material of interest is much smaller than in ordinary rotary drilling, ordinary hammering, or ordinary steady pushing.

The predecessor of the rotary percussive auto-gopher is an apparatus, now denoted an ultrasonic/sonic gopher and previously denoted an ultrasonic gopher, described in "Ultrasonic/Sonic Mechanism for Drilling and Coring" (NPO-30291), *NASA Tech Briefs* Vol. 27, No. 9 (September 2003), page 65. The ultrasonic/sonic gopher is intended for use mainly in acquiring cores. The name of the apparatus reflects the fact that, like a gopher, it pe-



Anchoring and Rotary Mechanisms and a fluted drill bit would be added to an ultrasonic/sonic gopher.

riodically stops advancing at the end of the hole to bring excavated material (in this case, a core sample) to the surface, then re-enters the hole to resume the advance of the end of the hole. By use of a cable suspended from a reel on the surface, the gopher is lifted from the hole to remove a core sample, then lowered into the hole to resume the advance and acquire the next core sample.

The rotary percussive auto-gopher would include an ultrasonic/sonic gopher, to which would be added an anchoring and a rotary mechanism and a fluted drill bit (see figure). If, as intended, the ultrasonic/sonic gopher were rotated, then as in the case of an ordinary twist drill bit, the flutes would remove cuttings from the end of the hole, thereby making it possible to drill much faster than would be possible by ultrasonic/sonic hammering and chiseling action alone. The anchoring mechanism would brace itself against the wall of the drilled hole to enable the rotary mechanism to apply a small torque and a small axial preload to rotate the ultrasonic/sonic gopher drill bit and push the drill bit against the end of the hole. The anchoring and rotary mechanisms would be parts of an assembly that would follow the ultrasonic/sonic gopher down the hole.

This work was done by Yoseph Bar-Cohen, Mircea Badescu, and Stewart Sherrit of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-45949

⚙️ More About Reconfigurable Exploratory Robotic Vehicles

Essential to reconfigurability is modularity of hardware and software.

NASA's Jet Propulsion Laboratory, Pasadena, California

Modular exploratory robotic vehicles that will be able to reconfigure themselves in the field are undergoing development. These vehicles at the initial concept stage were described in "Reconfigurable Exploratory Robotic Vehicles" (NPO-20944), *NASA Tech Briefs*, Vol. 25, No. 7 (July 2001), page 56. Proposed for use in exploration of the surfaces of Mars and other remote planets, these vehicles and others of similar design could also be useful for exploring hostile terrain on Earth.

To recapitulate from the cited prior article: the modular vehicles are de-

noted generally by the term Axeln, where n is an even number equal to the number of main wheels. The simplest vehicle of this type is Axel2 — a two-main-wheel module that superficially resembles the rear axle plus rear wheels of an automobile (see Figure 1). In addition to the two main wheels, an Axel2 includes a passive caster wheel attached to the axle by an actuated caster link. The motion of the caster link can be used to control the rotation of the axle in order to tilt, to the desired angle, any sensors mounted on the axle. In addition to the sensors, the axle of an Axel2 houses

computer modules and three motors and associated mechanisms for driving the main wheels and the caster link. An Axel2 is powered by rechargeable batteries located inside the wheel hubs.

One constructs an Axeln (n > 2) as an assembly of multiple Axel2s plus one or more instrument module(s) connected to each other at module interfaces (see Figure 2). The module interfaces contain standardized electrical and mechanical connections, including spring-loaded universal joints that afford some compliance to enable the modules to rotate, relative to each other, to adapt to