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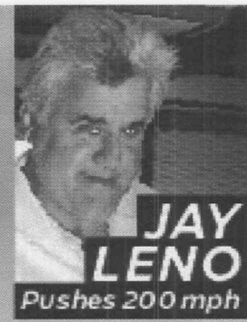

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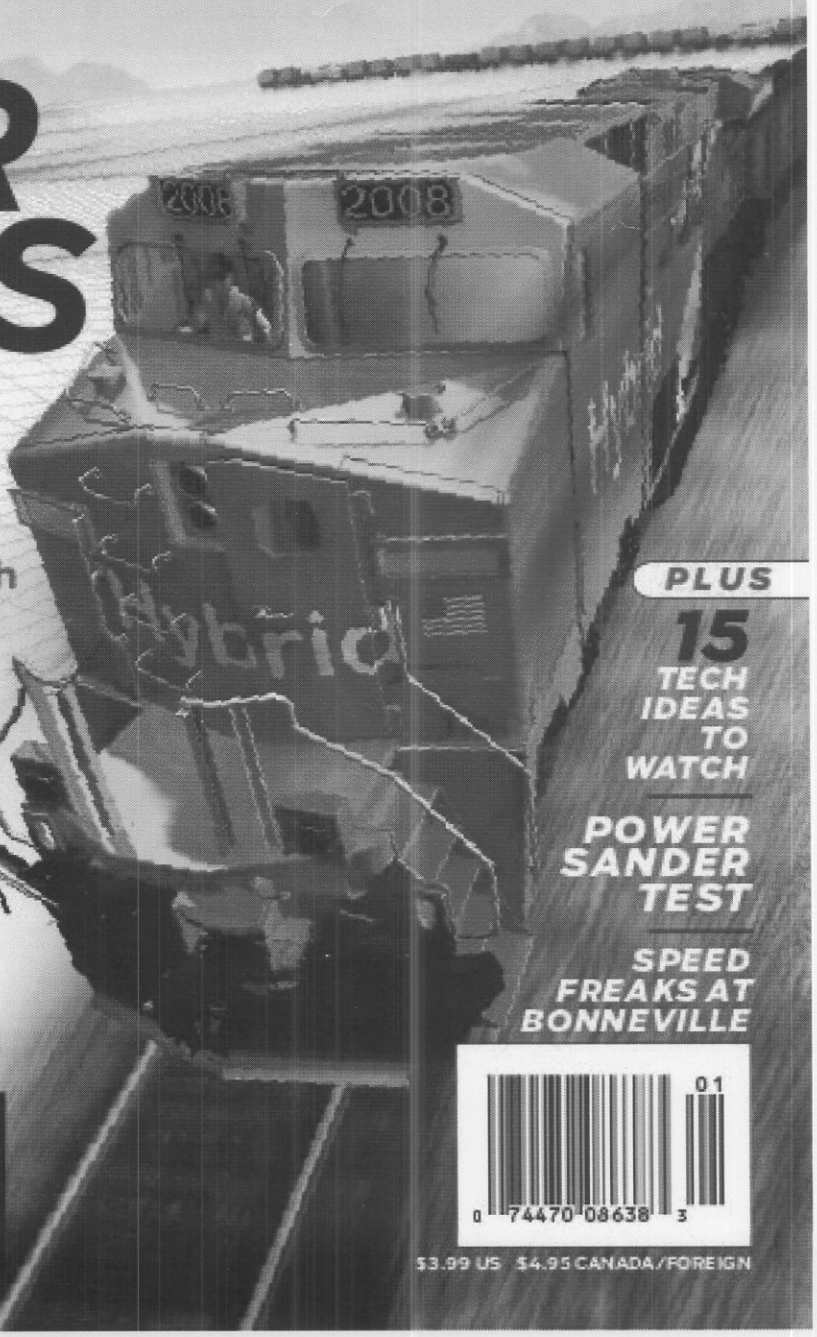

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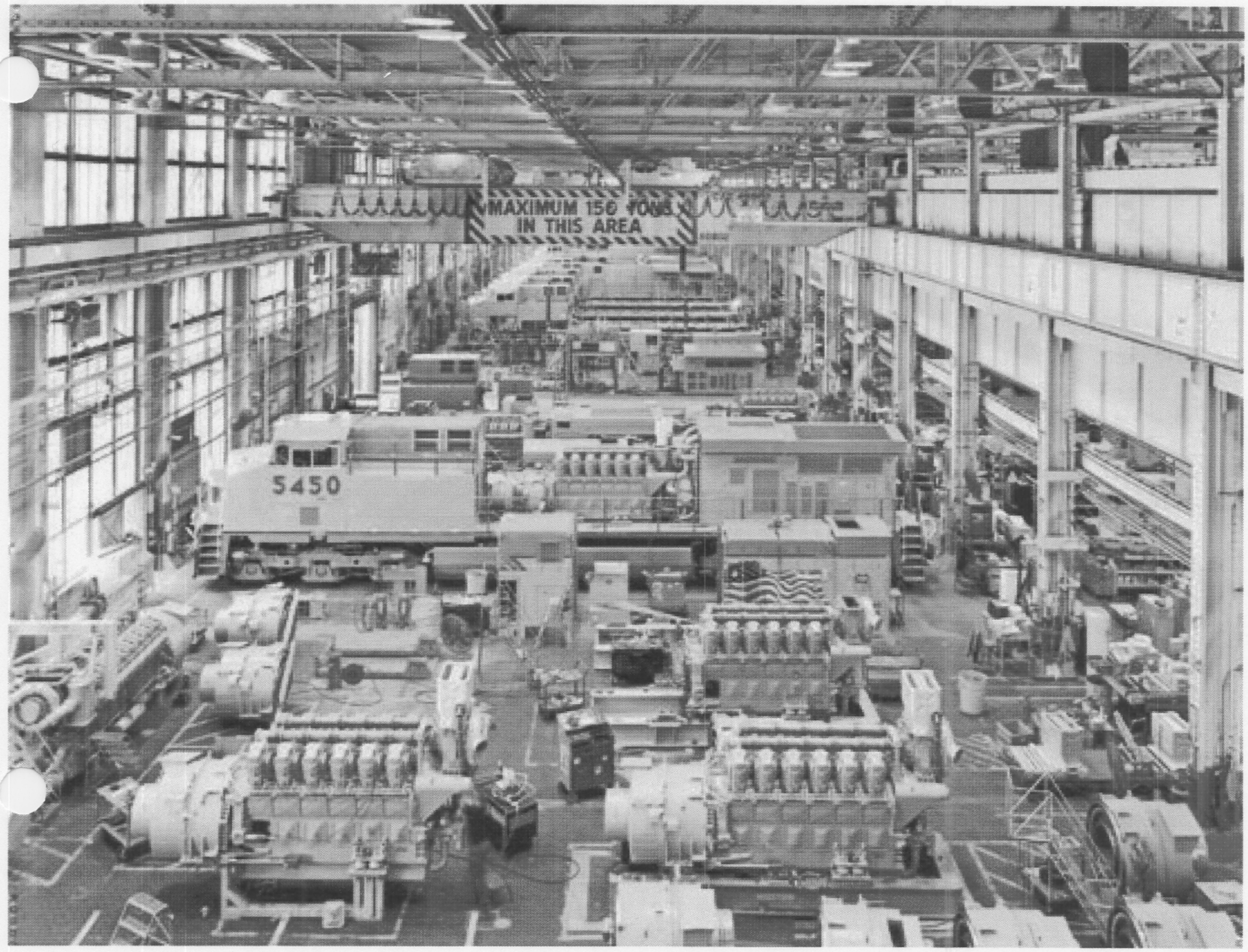


IMAGINE A MACHINE OF THE FUTURE that moves goods by the ton--by tens of thousands of tons--along specialized transportation corridors. Guided by computers, tracked by GPS and driven by powerful new engines, this revolutionary, high-tech vehicle slashes America's energy consumption and leaves the air cleaner than any mechanized transport before it. At a time when highways are clogged and fuel reserves are strained, it represents a miracle technology that arrives not a moment too soon. It's been under development for more than 200 years, yet it is the transportation of the future. Meet the freight train, reborn.

Railroading helped define development in the United States, but by the 1970s it seemed doomed to gradual decay and obsolescence. Today, it is a growth industry. "Railroads have led in innovation to a degree that people don't realize," says Gary Wolf, owner of Rail Sciences, a leading accident investigation firm. Railroads have helped pioneer computerized freight management, and have pushed the envelope on power, efficiency and mechanical ingenuity to move their cargo ever faster and more cheaply. Roughly 42 percent of all U.S.

freight moves by train, some 5 billion ton-miles per day on 140,000 miles of track. Volume records have been set each of the past three years--partly because it takes about a third as much fuel to move a ton of freight by rail as by truck. The innovations being introduced in the next few years will overshadow those of the past, with some of the biggest changes coming in energy efficiency. That's an arena where railroads already trounce the competition--and where the nation is in serious need of problem-solving.

RIDING THE GREEN LINE

FUEL EFFICIENCY COMES TOGETHER noisily under the roof of the 3.8-million-sq.-ft. General Electric factory in Erie, Pa., which is crawling with hundreds of electricians, welders, pipe fitters and helmeted supervisors toting clipboards. Pneumatic tools hiss and clatter as a crane arm lifts a massive locomotive assembly up and turns it over--manipulating 400,000 pounds of steel as if it were hollow tin. Once a crew has installed sensitive electronics on the undercarriage, the crane will deposit the 75-ft.-long, 16-ft.-high hulk of steel back onto the factory floor and the Evolution locomotive will have largely taken shape.

CLICK TO ENLARGE

FREIGHT LINER A GPS-linked unit high in the cab helps direct a 95-mph train near Kalamazoo, Mich.
PHOTOGRAPH BY COLBY LYNSE

The Evolution is a smarter, faster locomotive, designed to meet EPA emissions requirements that came into effect in 2005. It features a new control system, a new 12-cylinder diesel engine (producing as much power as its predecessor's 16-cylinder powerplant) and a first-of-its-kind air-to-air cooling system that helps the engine burn more cleanly. It will consume at least 200,000 fewer gallons of fuel in its lifetime than previous goliaths of the rails.

CLICK TO ENLARGE

Cargo comes by ship and leaves by rail in Long Beach, Calif.
PHOTOGRAPH COURTESY PORT OF LONG BEACH

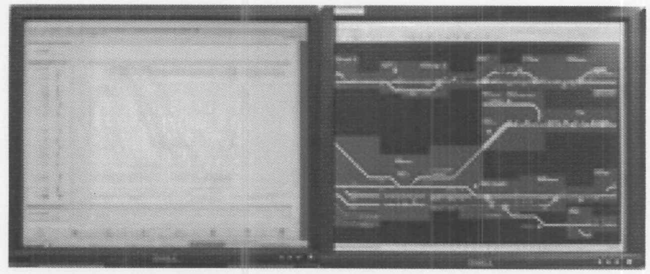
While the Evolution is being built, engineers at GE are already working furiously on a prototype for a still more efficient locomotive, a high-horsepower hybrid that captures energy given off by its brakes, just like a hybrid car. In one sense, virtually all American freight locomotives are hybrids: Their diesel engines turn alternators that feed current to electric motors. Additionally, locomotives supplement their airbrakes with dynamic braking, which helps slow a train by converting the motion of its wheels into electric current. Normally, this electricity goes to waste. However, the hybrid locomotive will store and reuse the energy--once engineers figure out how to harness a flow of electricity that dwarfs anything normal batteries can handle. The battery array has to store about 1500 kilowatt-hours, enough to run 50 American households for a day.

Once it works, though, the process should pony up about 2000 hp. Engineers expect the technology to cut fuel usage and emissions 15 percent below the Evolution's level. "If you replace all locos in North America with our hybrid, you will save half a billion dollars per year just in fuel," says the hybrid's project manager, Gagan Sood.

The planned locomotive won't be the first hybrid model. In 2002, Canada's RailPower Industries introduced the Green Goat, a low-horsepower machine, for use in switching cars at railyards. That's hurry-up-and-wait work that involves hours spent idling and, for most locomotives, belching clouds of nitrogen-oxide-laden exhaust that dirties the air and promotes acid rain. The Green Goat draws 85 percent of its energy from a 1200-ampere-hour battery made up of 336 2-volt cells; the locomotive produces just 10 to 20 percent of the NOx emissions of its pure diesel counterparts. It's already in wide use in the United States.

LONGER, STRONGER TRAINS

EVERY DAY, FIVE OR SIX cargo ships too massive to navigate the Panama Canal dock in Los Angeles and Long Beach, Calif. Each ship is packed with goods from Asia--tea bags and teddy bears and socks and shovels jammed into as many as 6000 containers, which are unloaded by $7 million cranes that can barely keep up with the workload. Most of these intermodal containers, which by definition can be loaded onto trucks or trains, depart the ports by rail to rumble on to destinations across the country. This freight is transforming the American railroad industry. The volume is increasing--the all-time weekly freight record was broken repeatedly in 2005--and disruptions can be disastrous. A 10-day lockout at West Coast ports in 2002 left more than 200 ships waiting to unload in port and out at sea.



CLICK TO ENLARGE

SWITCH BOARDS Norfolk Southern uses GE's movement planner in Georgia. Each train's progress is graphed individually (left) and shown on a detailed track map (right).

PHOTOGRAPHS BY ZACH WOLFE

The railroads' biggest job used to be point-to-point transport, such as taking coal or grain from the spot where it was produced to a power plant or port. It was only about two years ago that intermodal transportation became a bigger moneymaker. The growing traffic means that railroads need to move more goods in America's most heavily populated corridors. Unfortunately, adding new tracks costs around $1 million per mile--where it's feasible at all.

"The freight industry is like the electrical industry," says Rob Hoffman, a transportation analyst for World Business Chicago. "Nobody notices it until it inconveniences them. But when it shuts down, you see how quickly your supermarket empties." The simplest way to add capacity is to pack more cargo on each train--and the railroads have been doing that aggressively. The good news: It works. Today's double-stacked, 7000-ft. trains carry loads that far outstrip the cargoes of the past. The bad news: It's still not enough. Adding the needed capacity from now on won't require more brawn, but brain.

Click here to download a FREE pdf of GE's hybrid concept locomotive.

DIGITAL TRAFFIC CONTROL

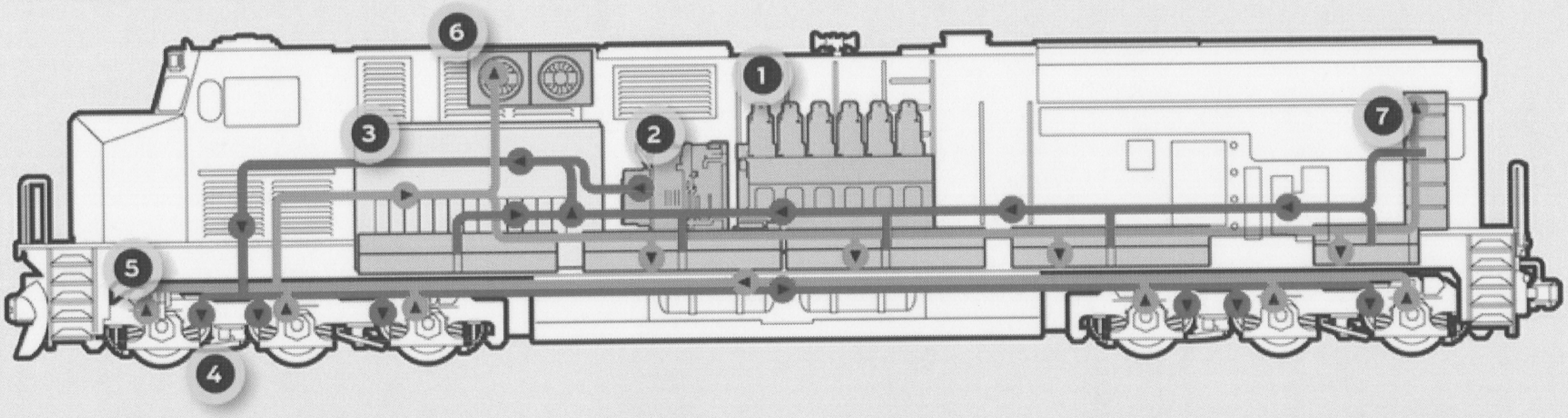
THE COUNTRY'S RAILS BUZZ with coal trains, high-speed intermodal trains, "manifest" freight trains that make frequent stops, and more--as many as 2000 trains at a time on each of the biggest companies' systems. Dispatchers monitor the traffic using two-way radios, gallons of coffee, and a cobbled-together mix of remote sensors, specialized software and stubby pencils. They must continually adjust train speeds and routing in light of endless variables, including track conditions, train maintenance needs, weather, cargo priorities and delays at crossings. The job is made tougher by the fact that up to 40 percent of the freight track in the United States remains unsignaled, or "dark." Dispatchers must space the trains far enough apart, and keep them moving slowly enough, to leave ample room for error.

"One way to add capacity is to optimize the traffic," says Prat Kumar of GE Rail Solutions, an incubator for new technologies. That means more trains moving faster over the same length of track. The company is one of several developing a computerized "movement planning" system that can automatically fine-tune schedules--taking much of the problem-solving burden off the shoulders of dispatchers. GE's system, which is now being tested in Georgia by Norfolk Southern, continually projects 8 hours into the future, revising its plan every 5 minutes. The experiment is being watched closely. Such systems have been tried before but, according to executives at other railroads, no system to date has successfully handled the ever-changing variables reliably and safely.

Positive train control (PTC), a related technology, can streamline the flow of information among crews and dispatchers. On most lines, engineers still use voice communications to get permission from a dispatcher to proceed--and they rely on their own eyes to tell if a shopping cart or stalled car spells disaster ahead. PTC provides instant updates on traffic, alerts on rail breaks and warnings about upcoming signal changes. It can even stop a locomotive from afar if a crew is incapacitated--or just missing. (It happens: In 2001, CSX employee Jon Hosfeld jumped aboard a runaway freight train to shut it down, but not before the train, carrying toxic chemicals, had barreled unmanned across northwestern Ohio for 2 hours after an engineer inadvertently engaged the throttle while getting off.)

Siemens is now installing a combination PTC, movement planner, operations center and automated security system throughout the New York City subway system. General Electric's own version of PTC has been in use on 71 miles of Amtrak line in the Midwest since 2002.

Hybrid on Rails



GE's hybrid concept is modeled on the Evolution locomotive, but—like a hybrid car—it stores energy generated when the brakes are applied.

The engine, a 12-cylinder, 4400-hp diesel (1), turns an alternator (2) to produce raw AC power, which is rectified into DC current and fed into a power bus (3). The bus distributes the power, which is inverted back to AC to drive the six axle-mounted motors (4). During braking, some of the energy of the wheels is converted into electric current (5). In the hybrid, some energy is dissipated as heat using a resistor grid on the roof (6), as in conventional locomotives. But most of the electricity is stored in a massive array of batteries (7), then used to help power the motors. The batteries would weigh approximately 40,000 pounds with today's technology, pushing the 210-ton locomotive past practical weight limits. GE is planning to compensate by refining the batteries and building the hybrid from lightweight composite materials.

DIAGRAM BY FLYING-CHILLI.COM

However, while PTC is cheaper than the older system of signals when new track is being laid, retrofitting existing lines is expensive. A nationwide rollout would cost $2 billion to $10 billion, according to the Association of American Railroads. Movement planning systems would be expensive, too, yet manufacturers such as General Electric say that such improvements can pay for themselves quickly. "We project that [our movement planning software] will be able to improve average velocity 2 to 4 mph," raising productivity sharply, Kumar says. "For a large railroad, 1 mile per hour equals up to $250 million each year."

Click here to download a FREE pdf of what the Future Train will do.

TRAIN SPOTTING--BY SATELLITE

FOR ANY DISPATCH SYSTEM to work, someone at headquarters needs to know where the trains are. Automatic Equipment Identification (AEI) tags have been mandatory on all freight cars since 1995. When a car passes one of the thousands of sensors positioned along much of America's mainline track, its location is transmitted to a tracking computer. (Additional monitors trackside scan wheels for defects and "listen" for signs of other mechanical troubles given off by passing trains.)

Positive train control, in contrast, requires constant, precise monitoring of each train's location, and so it relies heavily on an enhanced version of the Global Positioning System. "It's one thing to put GPS on golf carts," says Gary Wolf of Rail Sciences. "Nobody's going to be killed if your golf cart is off by a few yards. If you don't know exactly where your train is--on which track and in which direction it's going--you're looking at a potential catastrophe." The railroad industry is banking on differential GPS, which employs ground stations as well as the familiar network of satellites. Under ideal conditions, the technology can provide data that is accurate to within inches.

By mid-2005, Alaska Railroad had equipped its fleet of 62 locomotives with GPS, allowing it to keep an eye on all its trains and bringing light to the state's vast dark territory, where geography and distance make signaling and electrification nearly impossible.

Many specialized railcars throughout the country already are outfitted with GPS so that shippers can follow the position of delicate loads such as hazardous chemicals and perishables riding in refrigerated cars. Additionally, a company called Lat-Lon offers solar-powered, GPS-enabled RailRider units that can monitor the temperature of a load, shocks and accelerations, internal pressure, bearing temperatures and more. If it detects an "event," the RailRider sends both the location and the relevant data to a designated dispatch center. Lat-Lon currently monitors 2400 refrigerated cars, plus a number of hazmat tank cars that are outfitted with sensors to detect the release of agents such as chlorine gas.

Future Train

diagram by flying-chilli.com

Faster Data Flow

Up-to-the-minute information is critical if railroads are to move more freight without compromising safety. In a positive train control (PTC) system, locomotives are monitored using differential GPS, which relies on data from ground-based stations as well as satellites. The data is fed to a central control center, where dispatchers monitor factors such as track conditions, weather and delivery deadlines. Instructions and information are transmitted to each train wirelessly.

Cleaner Engines

Electro-Motive's 200-ton-plus, 4300-hp SD70ACe locomotive, illustrated here, meets new EPA emissions regulations. Between them, Electro-Motive and GE build most of the locomotives used in North America.

Bigger Loads

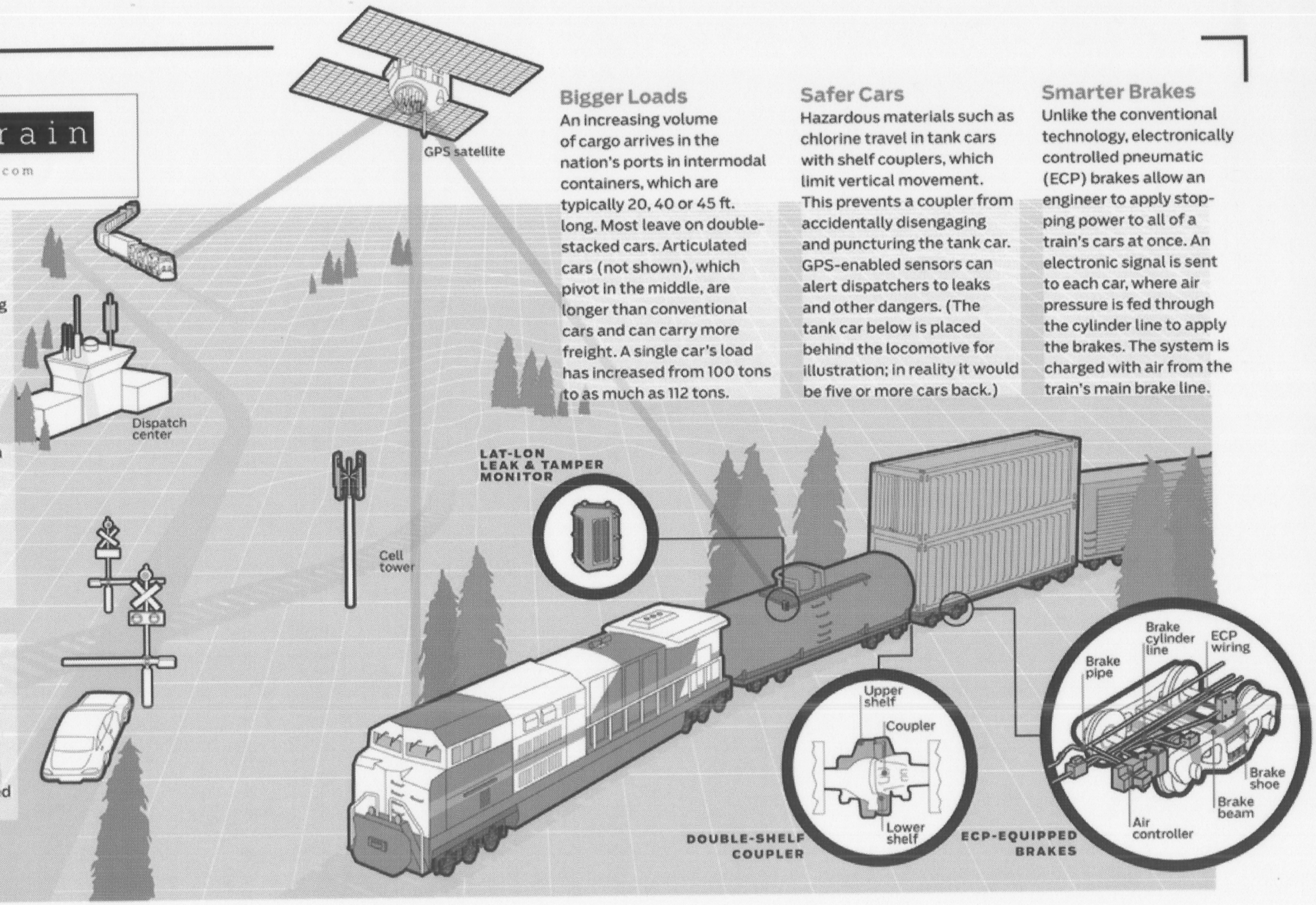
An increasing volume of cargo arrives in the nation's ports in intermodal containers, which are typically 20, 40 or 45 ft. long. Most leave on double-stacked cars. Articulated cars (not shown), which pivot in the middle, are longer than conventional cars and can carry more freight. A single car's load has increased from 100 tons to as much as 112 tons.

Safer Cars

Hazardous materials such as chlorine travel in tank cars with shelf couplers, which limit vertical movement. This prevents a coupler from accidentally disengaging and puncturing the tank car. GPS-enabled sensors can alert dispatchers to leaks and other dangers. (The tank car below is placed behind the locomotive for illustration; in reality it would be five or more cars back.)

Smarter Brakes

Unlike the conventional technology, electronically controlled pneumatic (ECP) brakes allow an engineer to apply stopping power to all of a train's cars at once. An electronic signal is sent to each car, where air pressure is fed through the cylinder line to apply the brakes. The system is charged with air from the train's main brake line.



STOPPING FASTER

IT WAS SHORTLY BEFORE 2 PM on June 10, 2005, when the engineer of an Amtrak train riding the rails--and there is a better way to stop. Today's airbrakes rely on a long pipe that "charges" each train car's brakes with air. To slow the train, the engineer releases air from the front; the air moves sequentially from car to car, triggering the valves to open and to apply pressure to the brake shoes. The process takes up to a second per car, and some trains have 150 cars.

New York Air Brake is one of several companies that offer electronically controlled brakes, [illegible] are activated electronically, via a pair of wires. By letting engineers apply all the brakes simultaneously, the technology can slash stopping distances--by nearly 70 percent in some cases.

the new system, the workers doing the switching operate the locomotives themselves, using wearable remote-control units.

The Federal Railroad Administration has begun allowing remote operation, under strict rules, on certain sections of open track. However, there may be too many grade crossings and stretches of dark, unsignaled territory throughout the country to make the technology widespread.

Perhaps that's a good thing. America's rails are destined to become more crowded, with powerful locomotives roaring along hauling the longest, heaviest loads anyone has ever seen. The next generation of trains will help drive the nation's business while combating energy short-ages. Their sophisticated new technology will be welcome--but it's comforting to know a human will still be at the controls.

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