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# The next wave of technological wonders

BNSF RAILWAY CO.

By Managing Editor Jeff Stagl and Senior Associate Editor Julie Sneider

Railroads are intent on grasping today's and tomorrow's innovations to gain better leverage with their efficiency and safety pursuits

**UNMANNED AERIAL VEHICLES**, or UAVs. Machine Vision. Instrumented Rail Inspection Systems. Driverless trains. Rolling data centers. Predictive analytics. The rail industry vernacular — which already includes hundreds of unique terms and acronyms — is rapidly adding new entries as industry stakeholders continue to assess and employ emerging technologies.

Whether it's to increase productivity, boost safety, enhance security, add convenience or just plain work smarter, freight and passenger roads are pursuing a host of innovations either solely or jointly with vendors. The technologies include some systems and software that still are in the development stage or are new to the rail industry.

It's all in the name of riding the next wave of technological advances, an exercise that figures to greatly help railroads adopt better ways of doing business or delivering services.

Members of the supply community are trying to negotiate that wave, as well, to continue to improve the products and services they provide to the rail industry. For several suppliers' perspectives on what's next in technology, see page 45.

In the freight-rail sector, Class Is are escalating their tap-the-latest-and-coming-technologies pursuit to glean operational and financial benefits. For example, CSX is advancing the adoption of a predictive analytics solution for locomotives.

Embracing technologies first and foremost enables a company to add value and do things safer, says CSX Technology President Kathleen Brandt.

"It can drive efficiencies in your own operations, to provide better information to customers and better information to communities," she says.

Automation also can help identify issues before something critical fails. Finding problems as early as possible helps improve asset management, says CSX Executive Vice President and Chief Operating Officer Cindy Sanborn.

"It's all about safety, service and assets," she says.

Union Pacific Railroad also aims to explore and validate innovations that can benefit employees, customers and communities, such as UAVs. Although many of the systems and software the Class I is embracing aren't necessarily leading-edge technologies or radical

departures, they ultimately will help fundamentally change the way UP does business, says Dan Rubin, the railroad's general director of information technologies.

"Technological advances allow us to improve the fluidity of our system, which then allows us to provide better service to our customers and a safe environment for our employees," he says.

Sometimes, an innovation that's been around for a long time — such as ground penetrating radar — can be a new rail technology if it's applied or tailored to railroads, says Rubin.

"We really are a niche market for technology, not a big purchaser like the government. As a vendor develops a technology, they aren't thinking about rail applications because we're not a major consumer for it," he says. "We need to get involved in the early stages of development to tailor it for a rail environment. Otherwise, we missed the boat."

## 'Vision' quest

For UP, playing a major role in the development of Machine Vision helped ensure the Class I wouldn't miss out on a seemingly valuable innovation. The erector-set-like portal contains sensors, cameras, lasers and strobes that inspect rail cars as a train passes by, providing a 3-D model and image of each car to identify any anomalies.

About three years ago, UP engineers and researchers began to determine if a system could be created to inspect more than a few things on a train. They worked with a number of vendors to develop Machine Vision as an open-source-based system incorporating many of the latest detection devices that can identify and measure 22 train components, says Rubin.

Trains undergoing inspections collectively sit in terminals for about 1 million hours annually. Machine Vision helps UP accelerate cars through a yard, reducing the risk of missed connections and improving network fluidity. Plus, advance inspections help supervisors and workers know what repairs need to be performed before a train arrives in a yard.

Each minute, the system — which currently is operating in Beck, Neb.; Loveland, Iowa; and Stuttgart, Ark. — processes and stores a terabyte of data, which equates to 17,000 hours of electronically uploaded music. UP hopes to eventually install additional Machine Visions around its network, says Rubin.

The Class I also aims to broaden its use of UAVs, which also are known as drones. Now in the early planning stages, UP officials are eyeing the deployment of a smaller class of UAVs that could accommodate payloads of less than 55 pounds.

The primary focus would be boosting worker safety, such as during inspections of the railroad's 700 radio towers, says

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Rubin. For example, a drone could perform an assessment of a tower. Then, an employee could bring all the tools and materials needed to replace a tower light instead of climbing a tower twice to both assess and complete the work, says Rubin.

In addition, a UAV could be used to perform bridge and aerial inspections.

### From pathfinder to pacesetter

BNSF Railway Co. already is using UAVs to inspect bridges and track. In partnership with the Federal Aviation Administration (FAA) through its Pathfinder Initiative, the Class I now is exploring other drone uses. Last year, BNSF was one of three companies awarded Pathfinder Program status by the FAA for extended integrity flights.

The railroad has found that smaller models can fly hundreds of miles and capture high-resolution images and videos of areas that are challenging or risky for workers to reach, such as underneath tall bridges. Since UAVs provide inspectors quality images of high, wide-span bridges, they no longer are put in situations that require fall protection, said BNSF spokeswoman Jessa Lewis in an email.

The Class I also is working closely with the FAA to lay a foundation for commercial UAV usage in the United States.

There's another way the railroad is striving to up its technological game along rights of way, especially when it comes to applying advanced or predictive analytics. BNSF teams are working with IBM Corp. experts to develop a system that can leverage data from several wayside detectors simultaneously to proactively predict operational issues before they occur.

Advanced analytics are aimed at drawing insights and value from large amounts of data, with the ultimate goal to improve



An erector-set-like portal containing sensors, cameras, lasers and strobes, the Machine Vision system developed by Union Pacific Railroad is designed to inspect rail cars as a train passes by.

decision-making, BNSF officials said in an email. Predictive maintenance provides sufficient intervention time to prevent incidents, they said.

Currently, more than 2,000 wayside detectors collect data 24/7 across BNSF's network and issue alerts about such safety issues as high-impact wheels, overheated bearings and damaged components. The detectors provide key data from more than 220,000 cars daily using a combination of laser, acoustic, infrared and vision-based technologies. An analysis is performed on more than 1.3 million readings per day to monitor equipment health, generate alerts and determine the severity of identified issues, BNSF officials said.

### Under evaluation

For CN, driving predictive analytics and data management also is vital to assess mechanical trends and identify opportunities for pre-emptive maintenance work. Plus, engineering forces can gain a better understanding of track health to prioritize maintenance and capital programs.

To that end, CN last year began using a Track Evaluation System (TEST) car that features the latest technologies for assessing track geometry, identifying missing and broken track components through optical imaging, and evaluating tie condition. The car can measure gauge, cross level, alignment, curve spirals and rail profile. The TEST car features inspection devices to inspect rail joint bars at track speed and identify cracked joint bars, which have been a cause of some recent major derailments.

CN worked with — and continues to team with — MER-MEC Inc., ENSCO Rail and Tetra Tech Inc. on the technologies employed on the TEST car, said CN spokesman Mark Hallman in an email.

The railroad also uses locomotives featuring accelerometer units to identify locations where unusual acceleration suggests potential track geometry issues.

For CSX, locomotives are a big part of a recent predictive analytics push. Since about 80 locomotives fail each year, the Class I this year embarked on a three-phase pilot project with Mtell, which uses machine learning technologies in conjunction with industrial assets to provide analytic solutions.

CSX provided oil sample data from more than 400 locomotives to Mtell, which under the first phase performed an analysis to identify possible failures or anomalies. The analysis revealed any increases in iron, viscosity soot level and antiwear, which meant an engine problem could be developing.

"It's all about looking for the signature of what's found in the oil, the chemical composition. Maybe there's an internal fuel leak," says CSX's Sanborn.

Under phase 2, CSX focused on 120 known failures (such as crank case overpressure and a hot running engine) and built a data model that helped predict engine failures 60 days before they occurred. A flagged locomotive was routed to a maintenance facility for testing, inspection and any necessary repairs.

Under phase 3, CSX subsequently changed locomotive maintenance processes. That meant no longer running parts to failure, performing preventative maintenance and proactively changing out components. The Class I



TEXAS CENTRAL RAILWAY

For its future high-speed train, Texas Central Railway selected the Tokaido Shinkansen N700-I bullet train technology primarily for its safety record.

also created a Prescriptive Performance Improvement Request workflow. Now, CSX is trying to replicate the model and workflow for its entire 3,500-unit fleet, beyond the 600 locomotives that were used in the pilot.

In the meantime, the Class I continues to roll out its “X-gate” inspection camera system/draymen mobile processing app at intermodal terminals. Introduced earlier this year, the app is designed to reduce the time draymen spend on manual paperwork processing and inbound/outbound inspections to improve terminal efficiency.

Information from X-gate — which as of late August had been implemented at seven of CSX’s 22 intermodal terminals — also helps each facility pre-plan truck flows. In addition, the cameras help boost security and assessment accuracy.

“The cameras can inspect containers at a high resolution, better than human eyes can. It helps with damage inspections,” says CSX Technology’s Brandt.

### Efficiency times five

Locomotives also are the major focus of Kansas City Southern’s innovation-adoption efforts. The Class I is implementing five technologies on locomotives to turn the motive power into “rolling data centers” that can operate safer and more efficiently, KCS officials said in an email.

By 2016’s end, the Class I plans to equip 76 locomotives with positive train control (PTC), energy management and remote monitoring systems, an on-board network and digital video recording (DVR) devices. By 2018’s end, 538 locomotives — a majority of its U.S. fleet — will be similarly equipped, KCS officials said.

The PTC on-board computer will identify the wayside

features of a track and help determine if action is needed to slow or stop a train, and alert the crew. The system will enhance safety and efficiency by providing crews with more information about upcoming track attributes and restrictions, KCS officials said.

In terms of energy management, the Class I for some time has been testing and validating a system to address fuel efficiency when trains are moving since train size, track conditions and locomotive handling can impact diesel usage. The energy management systems to be installed on the locomotives will help reduce the railroad’s carbon footprint and cut fuel costs, KCS officials said.

In addition, the technology can enhance safety because the systems’ algorithms will minimize in-train forces, helping to prevent derailments caused by slack or pulling forces, they said.

The adopted remote monitoring systems promise several benefits, too. They will keep tabs on locomotive location, fuel levels and engine data, such as temperature and pressure, to provide better information on asset utilization, train handling and fleet maintenance, KCS officials said. Remote monitoring also will provide real-time information about on-board systems so service can be performed before there’s a problem, they added.

“The future of locomotives includes predictive analytics [and] smart scheduling for inspections,” KCS officials said.

Meanwhile, the on-board network will serve as a communication gateway between all on-board systems and the back office, while the DVR systems will provide video images and recordings of both forward-facing and in-cab events. The network also will bolster security, ensuring only authorized users and systems have access to on-board systems, KCS officials said.

Each of the five technologies is supported by an antennae farm comprising a data radio, Wi-Fi, GPS and cellular communications for greater redundancy, reliability and cost-effective communications, KCS officials said. The Class I plans to provide employees training to obtain and maintain needed skills as the various systems are implemented.

The technologies don’t replace people who operate or maintain locomotives — they “empower people to run the operation safer, smarter and more efficiently,” KCS officials said.

When it comes to technological empowerment, passenger railroads are trying to amplify it by leveraging innovations that can improve riders’ comfort and convenience, and boost their systems’ safety, security and efficiency.

The technologies include smartphone apps, contactless fare payment cards, UAVs, robots and other methods that can help move the transit-rail industry closer to autonomous operations.

“The passenger experience will be a significant driver of innovation in the rail sector, and will be based on better service, loyalty and the ability to tailor preferences,” writes Colin Stewart, the global rail leader for consulting firm Arup in its report titled “Future of Rail 2050.”

### Rider experience, expectations

Passenger railroads will need to mind each individual rider’s trip, since “the future of service provision will be more about customized information and options, and removing barriers to the journey,” Stewart wrote. That means passengers will expect their train ride to offer level access, no waiting, smart ticketing, personal security and effortless planning.

In the future, passenger railroads also will need to focus on their riders' complete trip, beginning from their front step and ending at their destination's doorway. Riders will expect "integrated journey information and seamless connections to other transportation modes" that provide an efficient, hassle-free trip from start to finish, Stewart wrote.

In many cases, the technology that would allow such ease in rail travel is being deployed on passenger systems in Europe and Asia, but not yet in a major way in North America. One example is Transport for London's (TfL) contactless ticketing system. TfL worked with Cubic Transportation Systems (CTS) to introduce the TfL's Oyster card system in 2003. Cubic also assisted TfL in becoming the first public transportation provider in the world to launch a contactless, open payment system on its buses in 2012, and on the Tube and the national rail system in 2014.

"Now, anyone who has a contactless credit card can use that card to ride in London. You just tap it on your way into the [transit] system, tap it on your way out and the bill goes to your credit card," says Matt Newsome, senior vice president and general manager for CTS North America.

More than 500 million trips have been taken on TfL's system through the use of 12 million unique credit and debit cards from 90 different countries, as well as contactless-enabled mobile devices, according to CTS.

For TfL, CTS provided fare collection equipment on 8,500 buses, at 1,900 ticket gates at the London Underground and Overground stations, at 1,800 stand-alone validators, at 1,600 ticket machines and at the National Rail Stations where card readers are located. TfL developed the majority of the software and back office system.

In July, Cubic and TfL reached a \$20 million licensing agreement that allows CTS to adapt the TfL system for other transit providers. The system has transformed the way riders pay for transit in London, and has the potential to do the same in other cities around the world, Cubic officials say.

CTS has begun working with transit agencies in Chicago and Vancouver, British Columbia, to implement a ticketing program that's open to contactless chip cards. The system has been installed on the Chicago Transit Authority, but not many riders have used it yet because few people in the United States have such cards, according to Newsome. In Vancouver, TransLink hasn't yet implemented its open payment system.

North American transit agencies are likely to embrace the contactless open payment technology once it's readily available, industry observers say. Passengers will embrace the convenience of carrying one less payment card, while agencies will welcome the cost savings of not having to purchase, market and distribute their own fare payment cards.

Although innovative fare-payment mechanisms are a high priority for North American transit agencies, safety innovations top their technology wish-lists, says Randy Clarke, vice president of public safety and operations at the American Public Transportation Association (APTA).

"It gets down to our big goal, which is to make an already safe industry even more safe," he says.

### From Japan to Texas

For example, safety was behind Texas Central Partners' choice of an international version of the Tokaido Shinkansen N700-I bullet



The new Instrumented Rail inspection System, or IRIS, is a robotic vehicle that can be operated remotely from a portable base station for security inspection and emergency first response work.

train as the vehicle and system that will transport passengers on the Texas Central Railway, the private company's proposed high-speed rail line between Dallas and Houston that's slated for completion in 2021.

Although the Tokaido Shinkansen system has been operating in Japan between Tokyo and Osaka for decades, the technology would be a first for a U.S. passenger railroad. Texas Central Railway would feature the N700-I's core system — comprising the train, overhead catenary, track and signaling, maintenance and operations procedures — that have made Tokaido Shinkansen's operations so safe and efficient for more than 50 years, Texas Central officials say.

"We think for our application it is the best-suited technology — both in speed and reliability and in safety," says Gino Antoniello, Texas Central's senior director. "As a starting point, the Tokaido Shinkansen has an unprecedented safety record — there haven't been any passenger fatalities in its 50-year lifetime. We really are selecting the best technology statistically and historically."

Traveling at speeds up to 205 mph, the Texas Central train would transport riders on the 240-mile trip from Dallas to Fort Worth in less than 90 minutes, making it the fastest train in North America.

How can it move so fast and still be safe? The N700 has a streamlined, aerodynamic design, and is configured with traction motors and a propulsion system that allow rapid acceleration to high speed. A body-tilting mechanism and automatic train control enable the train to move safely through curves much faster than traditional high-speed trains.

The Shinkansen operates on electric power supplied by overhead catenary. An advanced regenerative braking system conserves and converts kinetic energy into electric power to slow the train.

Moreover, Texas Central's bullet train would run on steel wheels over a separate, secured and closed track that would be dedicated only to the bullet train's use. The track would not be shared with other passenger or freight trains, or cross roadway intersections. All that contributes to the bullet train's safety features, according to Texas Central.

"As far as the technology goes, it's not that far off into the future," says Antoniello. "We will take a proven technology and Texas-ize it a bit."

The project has been reported to cost around \$10 billion, with construction slated to begin in 2017.

While Texas Central works on bringing Japanese-style bullet-train technology to the United States, existing transit-rail systems are eyeing new technological developments that promise to enhance safety and security on existing lines. Among the options under consideration: UAVs and robots.

For example, Harsco Corp.'s Protran Technology subsidiary earlier this year formed a marketing alliance with Johns Hopkins University Applied Physics Laboratory (APL) to introduce unmanned vehicle technology to passenger and freight railroads for use in safety and security operations.

The new Instrumented Rail Inspection System (IRiS), a robotic vehicle, is equipped with near-infrared video and photographic capability, and can be operated remotely from a portable base station for security inspection and "first response" work without risking human safety, Protran officials say.

Johns Hopkins developed the technology with funding from the Transportation Security Administration, said Protran Technology Senior Director Jim Resio.

The university's APL has partnered with Protran to commercialize the vehicle, which has been tested on the Los Angeles County Metropolitan Transportation Authority's rail lines and by other transit agencies. Protran plans to make the IRiS platform commercially available to freight and passenger railroads, as well as to other markets in the transportation and mining industries.

"We're looking for that launch customer to take the project from a prototype to a fully commercialized vehicle," Resio says, adding that he believes the system will net a launch customer within a year.

The lightweight robot can be set up quickly to conduct basic security sweeps,

including scans under rail platforms for objects that aren't supposed to be there. It can accommodate optional sensors that can be used to detect chemicals or radiation at active events such as bomb threats, fires or natural disasters.

"The vehicle can be sent out to survey the situation without anyone getting hurt," says Resio.

The IRiS platform will be used only as surveillance equipment—it can't disarm a terrorist, for example.

### On automatic pilot

But with the public's growing interest in driverless cars, Resio believes sending a robot out into the field to work by itself eventually will become reality.

"We're several years out before doing that, but I think it will happen someday," he says.

Driverless passenger trains already are reality in some parts of the world, though not yet in the United States, says APTA's Clarke.

He describes four levels of autonomous operation on subways, with most U.S. agencies at a Level 2, which involves people opening the train doors, starting and driving the trains, but with automatic train controls running the signaling systems.

"Other agencies around the world are moving to a Level 3 and Level 4, with 4 being a train that would wake itself up by computer, run a schedule all day long and—assuming there are no anomalies—go back to the depot or yard at night and put itself to bed," says Clarke.

If there are operational problems, the train would be capable of self diagnosis, then move itself off the route and onto a maintenance track.

"That technology is being used in places like Singapore and Hong Kong,"

Clarke says, adding that APTA is part of a peer review project currently reviewing a new driverless rail system in Hong Kong.

Currently, TransLink's Skytrain system in Vancouver is the only fully automated train system in North America, according to Clarke. But the United States isn't too far behind: The elevated light-rail line under construction in Honolulu will be a fully automated system when it's completed in late 2021.

### Automation contemplation

Even though they are more expensive to build than traditional light-rail or subway systems, fully automated systems are expected to eventually become the norm for passenger rail over the next 20 years.

"Once the system is in place, you are providing an unbelievably safe environment," says Clarke. "You are eliminating all the variables that can occur, and setting a safety standard. The trains stop in the exact same place. All these systems have platform screen doors so no one can fall off onto the tracks. No one can fall off a train, and no one can walk onto the track without actually stopping the train's movements."

Although emerging technology will help transform rail safety, efficiency and reliability, it also figures to create new security concerns, cautions Clarke. That's a consideration both freight and passenger railroads will need to ponder as they continue to embrace innovations.

"The more integrated and complex our world becomes, the greater the cybersecurity challenge," says Clarke. "Transit agencies will have to be forward-leaning when it comes to facing threats to cybersecurity." ■

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