Stand beneath the new St. Anthony Falls Bridge in Minneapolis, and you can imagine the chaos on Aug. 1, 2007. Hundreds of people were stuck in rush hour traffic on that blazing hot day when, at 6 p.m., the bridge that formerly stood on the site collapsed into the Mississippi River in a matter of seconds. Scores of vehicles plunged into the water. Thirteen people died and 145 were injured.

The new bridge is no beauty. On a recent wintry day, the white 1,200-foot span looked plain and utilitarian. But this bridge is unlikely to crumple the way its predecessor did. It's packed with sensors and other electronics that constantly monitor the concrete for any weaknesses or structural damage. The St. Anthony Falls Bridge is one of the "smartest" bridges in the U.S.

Technology used in the planning, design, and construction helped make it possible for the entire process to be completed in just one year. The bridge opened for traffic in September, three months ahead of schedule, earning the builders a $25 million bonus. The sensors do more than keep track of maintenance needs. During Minnesota's bitter winters, they monitor weather conditions and automatically trigger an anti-icing system to prevent the roadway from freezing over. "The technology is about speed, it's about quality, and it's about efficiency," says Jon Chiglo, the civil engineer who managed the $234 million project for the Minnesota Transportation Dept.

Chiglo's bridge may be a sign of things to come. Over the next five years the U.S. is poised to spend more than $500 billion on infrastructure, more than the amount spent to build the entire Interstate Highway System in today's dollars. The money will come from President Barack Obama's stimulus package and a separate transportation bill that Congress is expected to approve in September. The avalanche of cash comes just as a host of so-called smart technologies is emerging to make it possible to build roads, bridges, mass transit systems, schools, hospitals, and electric grids faster and better, and to operate them more efficiently.

There are tensions over how smart to make the country's infrastructure, though. On one side, tech leaders portray this as an unprecedented opportunity for the U.S. to catch up with countries in Asia and the Middle East that have spent billions on futuristic cities and other projects in recent years. "Smarter infrastructure is by far our best path to creating these new, globally competitive jobs and stimulating growth," said IBM Chief Executive Samuel J. Palmisano in January, after meeting with Obama to discuss the stimulus package.
TECH SKEPTICS

Of course, IBM and other companies have a lot to gain from investments in tech-savvy infrastructure. Among the tech powerhouses, Cisco Systems, Accenture, and Hewlett-Packard are all launching new initiatives to profit from the opportunity. Construction giants Bechtel and Fluor are developing their tech expertise to gain a competitive edge, as are equipment makers such as General Electric and Siemens. Market researcher IDC estimates that sales of technology for infrastructure projects could top $122 billion by 2012.

On the other side of the debate are traditional construction trade groups and many politicians. They argue that the emphasis in government spending should be on creating as many jobs as quickly as possible, so old-fashioned brick-and-mortar projects make the most sense. "The problem with using [information technology]," says New York City Mayor Michael R. Bloomberg, "is you'll employ fewer people. It doesn't do a lot for keeping people employed."

Tech skeptics want to avoid the disasters of the past. Several tech-intensive projects, such as the E-ZPass automated toll-collection system in New Jersey, ran into long delays and huge cost overruns. The $500 million E-ZPass system launched two years behind schedule and cost the state more than $100 million, instead of paying for itself through higher collections and lower labor costs as originally predicted.

The federal government hasn't picked a side. The stimulus package says only that the money should go into "shovel ready" projects. The states will end up deciding how best to spend the billions that will be sent their way.

Chiglo has little patience for the advocates at either end of this debate. The tall and burly 36-year-old Minnesota native grew up watching his father erect dams and take on other projects to help farmers with soil erosion. Yet standing in a cramped office in the Transportation Dept.'s St. Paul (Minn.) headquarters, Chiglo explains that there are ways to incorporate technology into major construction projects without sacrificing speed or budgets--as long as they're managed properly. The cost of his bridge's sensor network amounted to less than one-half of 1% of the total price, or about $1 million. The priority, he says, is to get solid benefits without paying too much or becoming a guinea pig for unproven technology. "We don't want to experiment," says Chiglo.

The reality is that Chiglo and his counterparts in other states face a range of choices as the billions begin to flow from Washington: smart, smarter, or smartest. It may not make sense for them to pursue the bleeding-edge projects, where most of the money would go for high-powered computers and brainiac consultants. At the same time, Chiglo's experience suggests it would be foolish not to include at least some basic technology that would make infrastructure more effective, faster to build, and longer lasting. "We're not putting on Band-Aids," he says. "We plan to be energy-smart and resource-smart in the way we build and maintain our infrastructure."

Some states are following a similar path. Florida has requested $6.9 billion from the federal government, including some projects with technology components. "Including intelligent transportation systems has become a natural part of the considerations we give to any project," says W. David Lee of the office of policy at the Florida Transportation Dept.

But many more states look like they may put their stimulus checks into projects with no digital
smarts. The preliminary lists of infrastructure projects for the stimulus effort from states such as Oklahoma and Wyoming are predominantly for routine projects such as repaving highways and bridges. Not including any technology could prove to be a missed opportunity, experts say. "This stuff is relatively cheap," says C. Michael Walton, a civil engineering professor at the University of Texas at Austin. "And, if you save lives and avoid property damage, you get a significant cost-benefit ratio."

Technologies such as those used on the St. Anthony Falls Bridge are fairly easy to justify. Basic sensor networks have been used for years in dams and buildings, and prices have dropped to the point that they may make sense on safety grounds alone. The anti-icing system carries an added expense, but it saves the state real money because trucks don't have to spread sand and salt on the bridge. The U.S. Transportation Dept. estimates that such weather-management systems can lower snow and ice control costs by 10% to 50%.

Traffic-monitoring systems, made up of video cameras, sensors, and real-time Web feeds, also have clear returns, particularly in crowded metro areas. Researchers at Florida International University found that the $9.9 million annual cost of a system for Broward County yielded a benefit of $142 million in reduced travel time, fuel consumption, emissions, and secondary accidents involving rubberneckers.

"RESOURCE PRODUCTIVITY"

This intensive use of information technology in physical infrastructure projects represents a new direction for the computer industry. During the industry's 70-year history, the primary focus has been on making people more productive. Now computer scientists are increasingly focused on the potential for technology to help deal with the limits of the earth's resources—including energy, building materials, water, and carbon emissions. "Technology can have the same sort of impact on resource productivity as it has had on human labor," says Giulio Boccaletti, an expert in natural resource management at business consultancy McKinsey & Co.

Some of those considerations were on the mind of Alan Phipps when he first heard about the Minneapolis bridge collapse. Phipps is the director of operations at FIGG Bridge Engineers, a Tallahassee (Fla.) firm that specializes in designing complex bridges. He was in the Salt Lake City airport on Aug. 1, 2007, when a colleague called his mobile phone and told him to get to a TV fast. As the images of broken concrete and water rescues in Minnesota played out, Phipps' mind was racing. The state would want to replace the bridge quickly. It would want a structure that would last a long time. He had worked on a couple of projects that made limited use of sensors and data analytics software. This Minnesota project had "smart bridge" written all over it.

NUMBER-CRUNCHING

The Minnesota Transportation Dept. called for bids to rebuild the bridge quickly. Four teams submitted proposals by the Sept. 14 deadline, including the one made up of FIGG, Flatiron Construction, and Mansion Construction. The FIGG team was the only one to include smart-bridge technology in their proposal, but its bid was also somewhat more expensive than the other three. Five days later, it was declared the winner. Minnesota's six-person review committee
opted for the FIGG group because of its experience, the aesthetics of its design, and the smart technology. "They offered the best value overall," says Chiglo.

The team built several kinds of technologies into the bridge. A network of 323 sensors monitors the span for corrosion in the concrete, strained joints, or other structural weaknesses. The anti-icing system tracks the roadway's temperature and sprays potassium acetate when it gets cold enough for ice to form. There's also a traffic monitoring system, which detects the speed and volume of cars on the span. If there's an accident that blocks the roadway, information can be relayed to the Transportation Dept.'s central command so drivers approaching the bridge can be alerted or rerouted.

Digesting all the data streaming in from the bridge is no simple task. The Transportation Dept. is working with the University of Minnesota to develop new systems for crunching the numbers and putting them to good use. Catherine French, a civil engineering professor who is leading the effort, says the group will first establish a baseline of information to help monitor structural changes and the like.

As sophisticated as the St. Anthony Falls Bridge may seem, French sees big changes ahead. This bridge has a wired sensor network. The next generation will be wireless. That's much cheaper, making thousands of sensors affordable. Some people are even talking about applying sensors to surfaces in the form of a paint-like substance--so it works like human skin. How will thousands or millions of sensors be powered? One possible answer is harvesting the vibrations of the bridges as an energy source. "Those will be truly smart bridges," French says.

Sensor networks are at the heart of all sorts of smart infrastructure. San Francisco is rolling out a wireless network supplied by a startup called Streetline that detects when parking spaces are unoccupied. Motorists are directed to empty spaces either by displays on street signs or by maps on their smartphones. These projects just scratch the surface of the potential for sensor networks. Hewlett-Packard is rapidly developing nanoscale sensors and management software for what it calls a central nervous system for the earth. "We can build next-generation communities, either new cities or upgrades to existing cities," says Chandrakant D. Patel, a fellow at HP Labs. "We can create ecosystems that use much less energy."

The U.S. is just one part of the smart-infrastructure opportunity. Governments and companies across the world are upgrading transportation systems and electrical grids, erecting more efficient buildings, and otherwise adding intelligence to machines and structures. Abu Dhabi is spending $4 billion on infrastructure for its Masdar City, which is slated to be the world's first zero-carbon city. Instead of cars, Masdar will have driverless pods that carry people throughout the city. The government estimates that cutting-edge technologies will help it create 70,000 jobs and add more than two percentage points to Abu Dhabi's annual GDP growth.

So far, the U.S. has advanced more cautiously on the smart infrastructure front. Analysts expect the pace to pick up as states and municipalities become comfortable with the technologies and start adopting the best ideas from experiments around the country--say the traffic management system in Broward County or the wireless parking technology in San Francisco. Ultimately, the movement may evolve toward the visions put forth by technology giants: cell phones that alert drivers to nearby accidents, roads that reconfigure themselves to accommodate traffic flows, cars that drive themselves.

But those aren't the kinds of projects on the minds of people like Minnesota's Chiglo. As the
federal government begins doling out billions of dollars for projects across the country, he'll have a direct hand in guiding his state along a pragmatic path. Since the St. Anthony Falls Bridge was completed, he's been put in charge of overseeing Minnesota's 10-year transportation upgrade program. The effort already has a budget of $1.8 billion, and the state is requesting another $500 million from the Obama Administration. "We're going to rebuild things for the future," he says.

To see a video report on the construction of this high-tech bridge, go to http://businessweek.com/go/09/bridge

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