J. Richard Capka

DIAMOND DE TRIUMPH

Borrowing from the French, Kansas City designs a safer interchange

Over the next few years, Kansas City traffic will improve—and it has Paris to thank.

A diverging diamond interchange (DDI), born in the City of Lights in the mid-1970s, is currently under construction in Kansas City at the intersection of I-435 and Front Street. When completed, it will be the first interchange of its kind in the U.S. As new approaches are explored to ease traffic congestion, innovative designs like this will become more abundant.

It is not the first time American motorists have been helped by international influences. The DDI design is only the latest in a line of foreign roadway innovations that are enriching the American highway and helping to reduce traffic congestion. The Federal Highway Administration (FHWA) has spent years working with our international counterparts, studying their traffic problems, taking the best ideas from around the world and putting them to work for American drivers.

Roundabouts, or "rotaries" as they are known in certain quarters, which are growing in popularity as a cost-effective intersection with a long track record of safety, have their roots in the United Kingdom. Much of what we now know about the value of prefabrication in roadway construction comes from Japan, whose highway engineers are necessarily forced to keep construction times short. As FHWA touts through its Highways For Life program, there is value in building key road and bridge elements off-site, such as abutments, pilings and ramps. Assembling them on-site drastically shortens the time traffic is interrupted by road construction.

Even President Dwight D. Eisenhower, the father of the interstate system, applied what he learned from the German autobahn in World War II toward our present network of highways. The contributions to

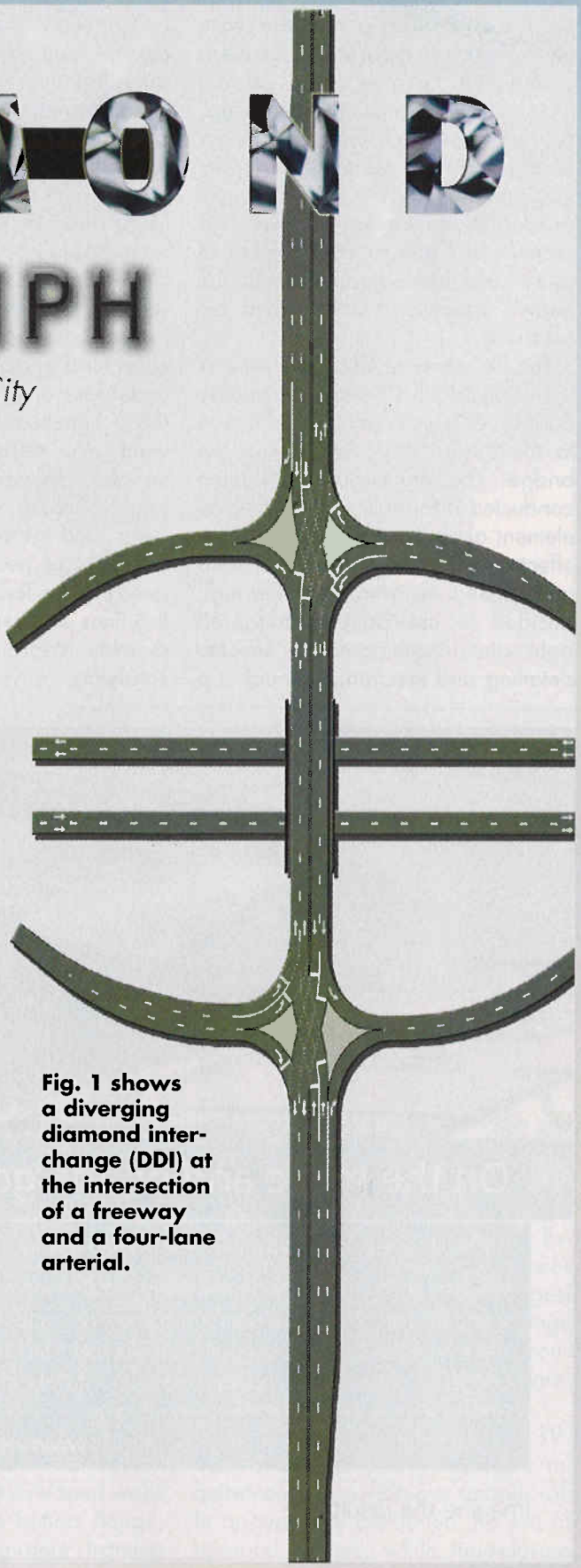


Fig. 1 shows a diverging diamond interchange (DDI) at the intersection of a freeway and a four-lane arterial.

the U.S. interstate system—the most sophisticated in the world—are as diverse as our nation itself and serve to make it the envy of other nations.

FHWA will never stop studying the work of our international colleagues because, as traffic congestion grows worse, interchange designs like Kansas City's DDI—as innovative as they are international—will become ever more common throughout the U.S.

Lines crossed

The concept of the DDI is to "cross" the cross street through lanes on the overpass (or underneath the main roadway) so that left turns can be made without conflicting with the opposing through direction of travel. The through lanes are crossed for only a short section between diamond ramp intersections and then cross back to be on the normal (right) side of the roadway. Once on the left side of the arterial roadway, vehicles can turn left onto limited-access ramps without stopping and without conflicting with through traffic. The crossover is made at signalized intersections. The chief advantage of the DDI is that signalized intersections on both sides of the over- or underpass require only two phases. A dedicated left-turn phase is not required. Neither the left nor right turning movement requires a traffic signal, unless needed for pedestrian crosswalks.

Where there is a large volume of left-turn movements, the traditional interchange design would require dedicated left-turn lanes. On the four-lane arterial shown in Fig. 1, two additional lanes would be required for left-turning vehicles, and left-turn signal phases would be required to accommodate those lanes.

Using high-performance computers at FHWA's research laboratory in McLean, Va., FHWA worked with the Missouri Department of Transportation (MoDOT) to create a computer model of the proposed DDI at the intersection of I-435 and Front Street in Kansas City, Mo. The model was built in FHWA's Highway Driving Simulator (HDS), a one-of-a-kind system blending real-time, 3-D computer imagery, engineering drawings, signing, marking and signal phasing, which allows design engineers to "drive" through the interchange before ground is ever broken. Driver performance of the proposed design can be evaluated under a number of conditions and compared against traditional interchanges.

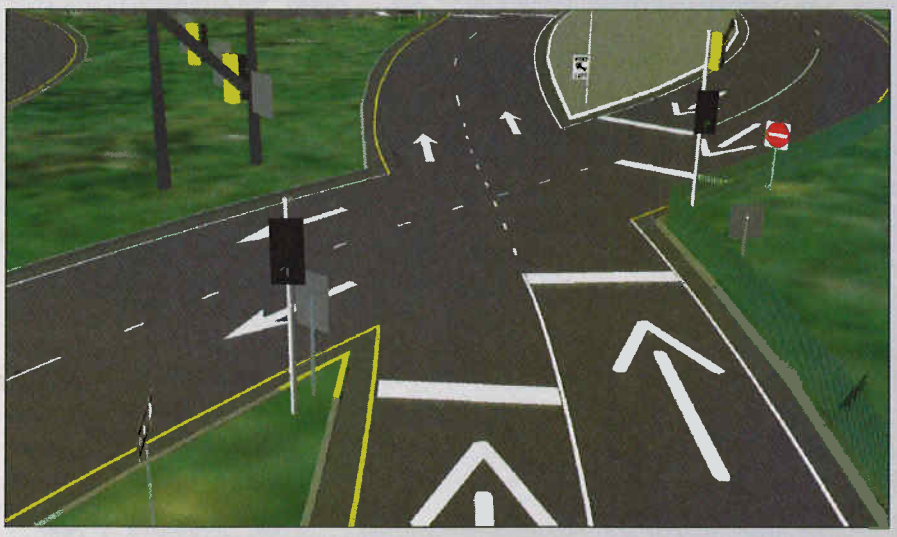
Based on their observations while driving through the various pathways through the interchange, the designers were able to request changes in signs, markings, geometry, roadway furniture and lighting and then drive through again to evaluate the changes. Able to simulate day or night driving conditions, street lighting, headlight patterns and traffic, the HDS creates a simulation that interacts with the simulator vehicle—a small sedan typical of the modern highway—allowing the driver to "feel" simulated road curvature and other physical elements long before they are actually built. More than 70 volunteer drivers were tested by FHWA's Human Centered Systems Team in this process.

Diamond is clean-cut solution

The DDI design provides a safety benefit in that it reduces the number of potential conflict points by eliminating potential crashes between vehicles turning left onto the highway from opposing arterial traffic. Fig. 2 shows conflict points for a four-lane DDI interchange in the upper panel and for a traditional diamond interchange design in the lower panel to accommodate similar traffic demand.

It can be seen that for the DDI there are two crossing conflicts, whereas with the diamond interchange there are four. The number of merging and diverging conflicts are the same for both designs. Simulations show that reducing the number of conflict points also reduces the number of injury and "property-damage-only" crashes. However, traffic signals are used to separate conflicts between vehicles, and other roadway design features, such as signs and markings, are intended to reduce crashes due to driver error.

Besides the potential safety benefits of the DDI, the design also offers operational and cost benefits over alternatives at grade-separated interchanges. MoDOT estimates that the Kansas City DDI will cost half as much as a conventional diamond interchange retrofit because the required ad-



Using high-performance computers at FHWA's research laboratory in McLean, Va., FHWA worked with the Missouri Department of Transportation to create a computer model of the proposed DDI at the intersection of I-435 and Front Street in Kansas City, Mo.

ditional lanes would call for excavation under the existing underpass.

Traffic can move more quickly through such an interchange than its counterparts because a DDI reduces the number of stops and improves the overall efficiency of the interchange. Also, because there are only two clearance phases, i.e., places where traffic stops, instead of three or more found at other interchanges, conflict points are reduced and driver safety is improved.

Also, by processing traffic more efficiently, a DDI can increase roadway capacity and reduce traffic congestion. Some experts say there is up to a 50% reduction in crashes, since there are no left turns crossing opposing traffic. Pedestrians and bicyclists can be accommodated through the interchange in a safe manner. Furthermore, traffic modeling suggests that the Kansas City DDI will be at 60% of capacity when completed while the traditional diamond interchange, a more expensive option, in this case, would be at 95% of capacity when completed and opened to the public.

After weeks of rigorous testing against other interchange designs, MoDOT personnel recommended the DDI design because of the improvements in driver safety and congestion relief. Moreover, other DDIs are being studied for possible use in Maryland along the Baltimore-Washington Parkway between Washington, D.C., and Baltimore-Washington International Thurgood Marshall Airport.

The language of progress

It should be said that DDIs are not the perfect solution for every situation, and that every mile of highway has special characteristics requiring tailor-made solutions. However, for the growth occurring in the Kansas City area—and for the growth anticipated over the next several decades—it is a very good one.

Also, Kansas City's DDI is testament to the creativity and innovation engineers are bringing to the problems of traffic congestion and maximizing highway system performance. By working with our international partners, through seminars, conferences, research partnerships and exchanges, the FHWA is contributing to an increasingly international body of literature that will keep drivers safe wherever they may be. Traffic congestion is not just an American problem, and roadway safety is an international language.

As an engineer myself, I encourage you to give some thought to the marvels of engineering that highways are as they stretch out like asphalt ribbons before you. Give some thought to the thousands of engineers, scientists and researchers who were influenced by international designs and played a part in keeping your drive safe and who took the time to drive the road hundreds of times before it was even built.

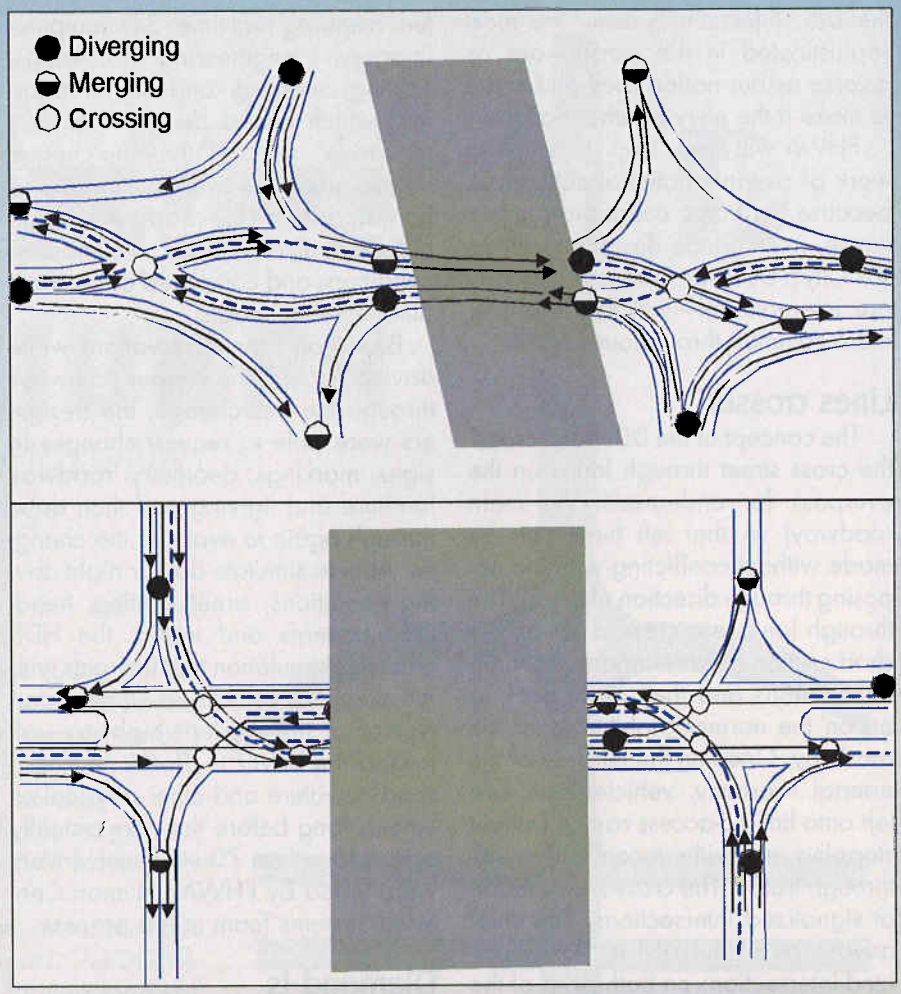


Fig. 2 shows conflict diagrams for DDI (above) and a traditional diamond interchange. Notice the diverging, merging and crossing points.

Capka is the administrator of FHWA, Washington, D.C.

LearnMore
For more information related to this article, go to:
www.roadsbridges.com/lm.cfm/rb080716