

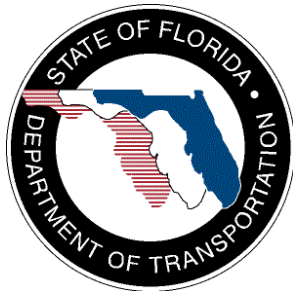
Technical Memorandum 1

Traffic Incident Management

Contraflow Implementation Experiences in the Southern Coastal States

March 30, 2006

Version 2



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*Technical Memorandum – Contraflow Implementation
Experiences in the Southern Coastal States*

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List of Acronyms

ALDOT	Alabama Department of Transportation
CCTV	Closed-circuit Television
DMS	Dynamic Message Sign
ESF	Emergency Support Functions
FDOT	Florida Department of Transportation
GDOT	Georgia Department of Transportation
HAR	Highway Advisory Radio
HOV	High-Occupancy Vehicle
IMAP	Incident Management Assistance Patrol
ITS	Intelligent Transportation System
LDOTD	Louisiana Department of Transportation and Development
MDOT	Mississippi Department of Transportation
MP	Milepost
MPH	Miles Per Hour
NC	North Carolina
NCDOT	North Carolina Department of Transportation
NCHP	North Carolina Highway Patrol
PSTN	Public Switched Telephone Network
SC	South Carolina
SCDOT	South Carolina Department of Transportation
SH	State Highway
SR	State Route
TEOO	Traffic Engineering and Operations Office
TxDOT	Texas Department of Transportation
U.S.	United States
VDEM	Virginia Department of Emergency Management
VDOT	Virginia Department of Transportation
VHF	Very High Frequency
VMS	Variable Message Sign
VoIP	Voice over Internet Protocol

1. Introduction

Due to the increased hurricane activity experienced in the 2004 and 2005 seasons, and due to indications that the heightened activity will continue for the next decade, Florida is actively updating its existing contraflow plans. Details of this ongoing effort are presented in the *Contraflow Plan for the Florida Intrastate Highway System*,¹ which supports the development of improved contraflow plans for particular portions of Florida’s limited-access interstates and certain expressways. In connection with this project, the Florida Department of Transportation (FDOT) Traffic Engineering and Operations Office (TEOO) is researching other state experiences, lessons learned, and best practices in planning and implementing contraflow (i.e., reverse-flow or one-way) operations to guide Florida in the development of route and infrastructure improvements plans.

The findings of the FDOT TEOO will be summarized in four reports, this document being the first of the four. This document introduces and discusses contraflow plans from various states and their experiences in implementing the plans, as applicable. Each state’s plan is briefly outlined and the implementation issues experienced are presented, along with the plan changes resulting from that implementation.

2. Alabama Implementation Experiences

The existing Alabama Department of Transportation (ALDOT) contraflow plan covers Alabama’s only reverse-lane evacuation route — Interstate 65 (I-65). The main purpose of the I-65 plan is to assist in evacuating traffic from coastal Baldwin County and the western Florida Panhandle. All traffic leaving Mobile on I-65 northbound is transitioned to the contraflow side of the interstate.

Only the Alabama counties of Baldwin and Mobile have Gulf of Mexico coastlines, and the primary evacuation routes out of these counties are State Route (SR) 59 and SR 113, both of which cross I-65 and have diamond interchanges at the interstate. The traffic evacuating on these routes enters on the I-65 regular northbound side. The ALDOT was recently asked to evaluate SR 113 for possible contraflow operations, but the ALDOT analysis concluded that this was not feasible.

¹ *Technical Memorandum – Contraflow Plan for the Florida Intrastate Highway System* (Version 1, June 2005), FDOT Contract No. C-7772. Available online at <http://floridaitis.com/Contraflow.htm>.

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The I-65 contraflow begins with a two-lane paved crossover having a design speed of 45 miles per hour (mph) at Milepost (MP) 31 before the SR 225 exit near Bay Minette. The route proceeds north and terminates at South Boulevard (MP 167) in Montgomery. South of the terminus, a third lane is added to northbound I-65 and a single-lane crossover is used to transition one of the contraflow lanes back to the normal northbound lanes. The other contraflow lane is forced to exit at South Boulevard and make a left turn onto South Boulevard.

Along the I-65 route, all entrances and exits on the normal northbound side remain open. On the contraflow side, traffic may exit at all interchanges but vehicles are not allowed to re-enter. The ALDOT staffs 30 locations along the route, using approximately 200 ALDOT personnel and approximately 60 Alabama State Troopers.

The ALDOT plan also includes practices that support contraflow operations, such as crossovers placed randomly along the route to allow balancing of traffic flow between the regular-flow and contraflow lanes; the use of static, fold-down, permanent signage; and dedicated traffic control equipment. The mid-route crossovers, while constructed, have not yet been used in conjunction with hurricane evacuation.

The ALDOT uses highway advisory radio (HAR) installations at the north and south ends of the contraflow route and has a phone bank at the ALDOT headquarters in Montgomery. The phone bank operates during all disasters and is part of an enhanced public affairs presence. The ALDOT also utilizes press releases to inform motorists of contraflow operations.

To support the plan and ensure that it is the best possible, the ALDOT requests critiques from each interchange team leader to indicate where improvements are needed. The ALDOT also meets with the local emergency management agencies every year around the beginning of the hurricane season to go over the plan and emphasize changes. At the end of each season, they have a followup meeting with the Alabama Department of Public Safety to review what changes should be made next season.

One area of concern is communications; the ALDOT is limited to a SouthernLINC Wireless® network whose phones also function as radios.² After Hurricane Katrina, the loss of cell towers and switches reduced SouthernLINC service to radio only in many locations. The ALDOT continues to rely on its legacy maintenance very high frequency (VHF) radio system as a backup communications system.

The I-65 contraflow plan was changed prior to the 2005 hurricane season based on the ALDOT's experience with implementing the plan in 2004. The plan was modified to force southbound I-65 traffic to exit at Fairview Avenue, which is one exit north of South Boulevard. In 2004, the plan called for both northbound evacuating traffic and southbound traffic to exit at the South Boulevard interchange.

² SouthernLINC Wireless is a registered trademark of SouthernLINC Wireless. More information regarding SouthernLINC Wireless systems is available online at <http://www.southerlinc.com/>.

The plan will also be changed to relocate the north end of the contraflow operation to the United States (U.S.) Highway 31 interchange. Improvements are being made to U.S. Highway 31, which will become a four-lane facility when construction is complete. Further changes occurred to the plan based on experiences from Hurricane Dennis in 2005. These include minor interchange pavement improvements at Exits 37, 69, and 114 to allow division of the I-65 entering traffic between regular-flow and contraflow; setup of detour routes for southbound detouring traffic in Montgomery; and more lane closures.

Beyond the physical changes to the plan, the ALDOT also decided to change the decision-making criteria for implementation. Originally, the I-65 contraflow plan was designed to be executed in response to predetermined traffic flow levels.³ However, in future implementations, the plan will be executed based on a scheduled time established in response to a specific hurricane scenario. These changes were based on different factors experienced by the ALDOT in 2004 during the activation of the plan during Hurricane Ivan, which included longer-than-anticipated time to clear the southbound I-65 lanes for contraflowing and longer-than-anticipated time to set up the required equipment for Alabama's contraflow plan.

Other changes were prompted by contraflow implementation for Hurricane Dennis, in particular the need to specify that contraflow operations start a full daylight period before the hurricane's predicted landfall and run only during daylight hours.

3. Georgia Implementation Experiences

The Georgia Department of Transportation (GDOT) has contraflow plans for Interstate 75 (I-75) and Interstate 95 (I-95), as well as Interstate 16 (I-16). None of these plans, as currently developed, have been implemented. The main purpose of the plans for I-75 and I-95 is to provide additional capacity for the remaining four-lane sections of these roadways. The I-75 contraflow plan addresses the four-lane section around the Valdosta area and the I-95 operation is in the Brunswick/Glynn County vicinity. Both of these areas are currently four-lane roadways that have six-lane segments on either side of them. However, both of the areas have projects programmed that will widen them to a minimum of six lanes. When this is completed, it is expected that contraflow operations will no longer be needed on these interstates. The GDOT, however, wants to install barrier gates similar to those in place on I-16 between Dublin and Savannah. These gates would be added on all ramps along southern I-75/I-95 for additional preparedness.

³ Alabama Department of Transportation Maintenance Bureau, *I-65 Reverse-Laning for Hurricane Evacuation* (Rev. June 2005). More information regarding the ALDOT's current contraflow plan is available online at <http://www.dot.state.al.us/Docs/Bureaus/Maintenance/Maintenance+Index.htm>.

The I-16 operation extends west from Savannah, with multiple crossovers to position traffic on the contraflow side. The operation ends in Dublin with a single-lane crossover to remove traffic from the contraflow side. The plan includes hand-crank barrier gates on all exit and entrance ramps to restrict traffic from entering/exiting contraflow operations as needed. The I-16 plan also includes the use of six ADDCO SmartZone® trailers, which are placed on asphalt pads constructed outside the shoulder area.⁴ SmartZone trailers have a portable variable message sign (VMS), closed-circuit television (CCTV) camera, HAR, and data collection systems, all on a single-trailer chassis. The trailers have telephone connections that enable them to relay data back to Atlanta for control and monitoring. There are also approximately three overhead dynamic message sign (DMS) devices that can be used to support operations, as well as approximately four slow-scan CCTV cameras on I-16, all of which are operated and viewed from Atlanta as well.

The GDOT noted that the contraflow plan will be implemented during daylight hours only. It is likely that the plan will be implemented the day before a hurricane's landfall; however, a set scenario has not been decided, nor has a plan for device retrieval before the storm been established.

The GDOT further noted that both their resources and the Georgia State Patrol resources are stretched thin. This requires more responsibility to fall on local law enforcement. This staffing demand also reinforces the need to place barriers along the ramps rather than assigning personnel and vehicles to remain at these locations.

4. Louisiana Implementation Experiences

The Louisiana Department of Transportation and Development (LDOTD) is one of the state agencies that have implemented its contraflow plan during each of the last two hurricane seasons: first prior to Hurricane Ivan in 2004 and then again prior to Hurricane Katrina in 2005. Louisiana's contraflow plan involves Interstates 10, 55, and 59 — I-10, I-55, and I-59, respectively — and depends on successful coordination with Mississippi to ensure that people are evacuated adequately out of harm's way.

A secondary goal of the overall contraflow/evacuation plan for Louisiana, beyond evacuating the New Orleans area, is to minimize congestion from the evacuating Mississippi and Texas traffic that enters Louisiana on I-10 or Interstate 12 (I-12), and from the local traffic evacuating New Orleans. The Louisiana experience during the 2004 season prompted the LDOTD to redesign its contraflow plans to address these primary goals of evacuating traffic and minimizing traffic flow conflicts.

⁴ SmartZone is a registered trademark of ADDCO. More information regarding the ADDCO SmartZone traffic management system is available online at http://www.addcoinc.com/t_smart.htm.

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Prior to Ivan in 2004, the Louisiana contraflow plan for I-10 westbound from New Orleans had single points for both loading and unloading. The I-10 loading point was at the Loyola Drive interchange in New Orleans. A single, two-lane crossover point at the I-55 interchange forced regular-flow traffic north on I-55; contraflow traffic crossed over to the conventional flow side downstream of the I-55 interchange. Eastbound I-10 traffic was forced off at the U.S. Highway 61 LaPlace interchange. Most of this westbound I-10 contraflow route is on what is known as the 12-Mile Bridge. The contraflow plan as implemented in 2004 did not allow any entry or exit along the section of I-10 being contraflowed.

As a consequence of the above-described contraflow activities, there was a significant bottleneck at Baton Rouge in conjunction with traffic evacuating Mississippi, Alabama, and Florida. This bottleneck extended upstream from the Mississippi River Bridge on I-10 because Interstates 10 and 12 merge just east of Baton Rouge, reducing the five-lane westbound capacity to two lanes at the Bridge. Interstate 12 is a relatively short route that provides motorists a means to bypass the New Orleans area on the north side of Lake Pontchartrain.

In response to the implementation experience during Hurricane Ivan, the plan described above was reevaluated and reengineered prior to the 2005 hurricane season. Among the specific improvements identified was the need for more loading and unloading points, and the need to ensure evacuating traffic was accommodated to the best extent possible to the Mississippi state line. The revised contraflow plan addresses I-10, both west and east of New Orleans, and is outlined below.

For eastbound I-10 traffic west of New Orleans, the west part of the revised plan continues to force those vehicles off at the U.S. Highway 61/LaPlace exit to clear the eastbound side for contraflow operations. The LDOTD also added multiple loading points east of the 2004 beginning point at the Loyola Drive interchange, but retained the original use of the I-10 section west of New Orleans on the 12-Mile Bridge. As part of this, motorists desiring to go to Baton Rouge are directed (using portable VMS) to the contraflow side because the regular flow side is forced to exit to northbound I-55, which heads to Mississippi. There is no exit/entry allowed on the contraflow side with the exception of the LA 16 exit on I-55. There, people traveling on the contraflow side were allowed to access motorist services, but there was no exit allowed from the regular travel lanes.

The east part of the plan has the I-10 westbound traffic from Mississippi being forced to exit north onto I-59 to eliminate significant westbound I-10/I-12 traffic flow heading toward Baton Rouge. The shoulder of the westbound-to-northbound ramp at the I-10/I-59 interchange was widened to allow for two lanes of traffic from westbound I-10 to northbound I-59. This portion of the plan also has a shoulder-use component for eastbound I-10 on the 5-Mile Bridge as it heads northeast from New Orleans. (This bridge and the 12-Mile Bridge were originally designed as three-lane bridges, but were striped for two lanes of traffic.) Traffic on I-10 eastbound from New Orleans is then shifted over to the contraflow side at the I-59 interchange. From there, traffic continues on the contraflow side across the Mississippi state line to MP 23 near Poplarville.

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Louisiana uses other technologies and practices in support of its contraflow operations. These include public information such as handouts that are distributed to newspapers and aired on television newscasts, the use of intelligent transportation system (ITS) services to support the operations, and implementing special signal timing at intersections for the evacuation. There are 24 CCTV cameras in the Baton Rouge area and approximately 6 CCTV cameras in New Orleans that were used to support the operations. The CCTV cameras mounted on microwave towers were utilized as well. For southern Louisiana surface routes, such as U.S. Highways 61, 90, and 190 that were used as evacuation routes but not contraflowed, previously developed evacuation signal timing plans were implemented from the transportation management center or by technicians on site.

Beyond the initial lessons learned during Ivan that altered the contraflow plan, there are several other areas that LDOTD felt needed improvement, based on their Katrina experiences:

1. Communications failed early during Katrina. The public switched telephone network (PSTN) failed during the storm. Satellite phones didn't work. The cellular system went down except for the data side (which carries text messages) and the Nextel® walkie-talkie function.⁵ As a result, the Louisiana State Patrol used Dish Network® high-speed Internet access coupled with Voice over Internet Protocol (VoIP) telephones for communication.⁶
2. The LDOTD traveler information system was found to be lacking. Between too few communication networks and LDOTD's lack of procedures for field-to-center communications, the information received was poor and the management of the information was deficient.
3. There was a statewide call center set up, but most of the information being kept (principally road condition data) was of inconsistent quality due to the conditions noted in the previous items.
4. There was a general lack of data on the operations. The LDOTD would like to upgrade its communication capabilities by improving the existing statewide microwave communications system and by installing field hardened Ethernet® switchgear.⁷

⁵ Nextel is a registered trademark of Sprint Nextel Corp. of Reston, VA.

⁶ Dish Network is a registered trademark of EchoStar Satellite LLC of Littleton, CO.

⁷ Ethernet is a registered trademark of Xerox Corporation.

5. Mississippi Implementation Experiences

Mississippi has two main contraflow routes, I-59 and I-55, which are in place specifically to assist the evacuation of an estimated 1.4 million people from southeastern Louisiana. Seven north-south highways that are classified as “limited controlled access routes” by the state serve Mississippi’s estimated 364,000 coastal residents. While all of these roads are designated evacuation routes, none of them provides a viable option for a contraflow to serve Mississippi residents, according to the Mississippi Department of Transportation (MDOT).

Interstate 59 was the original contraflow route that the MDOT developed for use prior to Hurricane Ivan. In early 2005, Louisiana officials requested a similar contraflow plan for I-55. The MDOT was able to quickly develop a plan for I-55 and have it completed one week before Hurricane Katrina arrived in 2005. Both the I-55 and I-59 routes were used during the Katrina evacuation and worked well.

The I-59 route in Mississippi is approximately 21 miles long and begins at the Louisiana state line. It ends at Poplarville, where the plan reduces the two lanes of contraflow to one lane and uses a single lane crossover to bring traffic back to the regular flow side. The I-59 contraflow plan was initially designed to run to MP 90 but, due to public safety input, the MDOT shortened the route. The original plan (up to MP 90) had two intermediate crossovers and then one final crossover. The I-59 route does get some traffic from Hancock County in Mississippi.

The I-55 route is approximately 31 miles long and begins at the Louisiana state line with the same termination/tapering strategy as the I-59 route. This route is solely for Louisiana and ends at Brookhaven, Mississippi. Motorists using either of these interstates in the northbound direction can eventually take such east-west highways as U.S. Highways 84 or 98, or Interstate 20 (I-20).

Under the arrangement between Mississippi and Louisiana, a mutual contraflow is implemented under one of two options, based on the potential for a major hurricane tracking toward New Orleans and the resulting high storm surge, which would produce unmanageable traffic congestion. Under Option 1, the LDOTD conducts its contraflow operations within Louisiana. Under Option 2, the Louisiana governor contacts Mississippi’s governor and they agree to extend the LDOTD contraflow further north into Mississippi, where the MDOT takes over.

During the Katrina contraflow operation, the routes worked well overall, although there were backups on both routes — 14 miles on the regular flow side and 7 miles on the contraflow side. Motorists attempted to balance these two queues by crossing the median to equalize the traffic flow. Also, after Katrina and in conjunction with reentry, one lane on I-59 from Hattiesburg southward was self-contraflowed in the southbound direction, most likely because it was the only “cleared” lane. It is imperative to note that self-contraflowing by motorists is extremely dangerous and should be avoided at all costs.

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The MDOT's southern district personnel provided staffing for contraflow operations in shifts. The people located across the middle of the district staffed the first shift, and the second shift by those from the north section of the district. Rather than staff potentially returning for a second shift, the preferred method was for each shift to work 20 hours. The Mississippi Highway Patrol is assigned to patrol the contraflow routes, while the MDOT employees staff the interchanges. The MDOT recommends putting more patrol staff on the contraflow side of the highway to ensure quick clearing of disabled vehicles and to have reentry traffic able to flow safely and unobstructed.

The MDOT officials reported that although they did contraflow when requested by Louisiana for Katrina, Mississippi residents did not evacuate in a large-scale sense. In fact, more evacuated before Ivan than before Katrina. They relate this to the storms changing path and the lack of accurate information on the size and strength of the approaching hurricane. They also noted that people become desensitized to evacuations, so emergency management must "pre-pull the trigger" for contraflow by deploying and readying resources just in case. This explains why, if a storm enters the Gulf of Mexico, the MDOT mobilizes for reverse-lane operations.

One of the pinch points for eastbound evacuating traffic through Mississippi is the I-10 tunnel in Mobile, Alabama, as was identified by the MDOT during helicopter surveillance on the Sunday before Katrina. Eastbound evacuating traffic backed up 70 miles from the tunnel all the way to Gulfport, Mississippi.

The MDOT has several other supporting practices they use to assist in contraflow operations. These include the use of flip-down static signs for exit numbers and exit city names to show the contraflow motorists where they are. At interchanges, where they allow access, the MDOT has found it good public relations to have people available to answer questions, and offer maps or brochures to evacuees. The MDOT also formed an improvised motorist aid patrol with MDOT mechanics driving trucks to assist broken-down vehicles. The MDOT did identify a specific reverse-flow route to allow service vehicles to return to the beginning of the contraflow. They also used manual control of traffic signals at contraflow exits.

Another major issue MDOT officials noted was communications. They said it is imperative to have statewide communications. Their current communications is provided by cellular service provider SouthernLINC and the MDOT made certain that there was a SouthernLINC telephone present as part of the contraflow equipment at every interchange. This system worked well, but a new state-owned radio network is under development that should be in place for the 2007 hurricane season.

The MDOT also uses ITS to support contraflow operations. They have a few CCTV cameras, mainly on I-10, which are used to monitor evacuations. They also employ 22 portable VMS in District 6 (the coastal District) and 5 more in District 5, the next district north. However, from the MDOT perspective, the portable VMS units are very high maintenance and are relatively fragile.

After doing an after-implementation review, there are no major changes expected to the plans, the MDOT concluded. However, it was noted that the MDOT would like to reduce the use of traffic barriers by approximately 60 percent to speed up deployment and they would also like to have more portable VMS.

6. North Carolina Implementation Experiences

In 2000, North Carolina developed an Interstate 40 (I-40) contraflow plan in response to Hurricane Floyd, which threatened much of the Atlantic Coast in September 1999. This plan outlines contraflow operations for approximately 90 miles of I-40 beginning in Wilmington and ending just before the I-95 interchange. The plan includes median crossovers at the beginning along College Road (North Carolina [NC] State Road 132) and at the end within the six-mile segment immediately before I-95. The plan will be executed during daylight hours the day before a hurricane's expected landfall to allow recovery of the field hardware before the storm hits.

The plan currently allows for exit and entrance to the contraflow side of the operation, but the North Carolina Department of Transportation (NCDOT) is concerned about a potential traffic imbalance, so consideration is being given to not allowing access to contraflow lanes. The NCDOT's other main concern is truck traffic — the plan starts where it does to ensure that truck traffic ends up on the regular-flow side.

The plan also includes the use of CB Wizard,⁸ HAR, VMS devices, the use of the North Carolina Incident Management Assistance Patrol (IMAP) program,⁹ and the stationing of tow trucks at the first interchange in each county during plan reversal. North Carolina has also implemented other practices to support the contraflow plan. These practices include painted interchange numbers on the road so that North Carolina Highway Patrol (NCHP) planes can identify the interchanges as they patrol contraflow operations; delineators on the terminal end of guardrails so they won't need to be retrofitted during contraflow operations; marked message sign locations on the pavement and small indicator signs; and the use of radios and telephones for communicating with IMAP, maintenance vehicles, and the NCHP.

It is noted that the NCHP and public safety personnel have their own plans for one-way operations. The NCHP version is a detailed interchange-by-interchange plan that outlines where agency resources should be stationed. All the plans were developed in conjunction with the NCDOT plan to ensure coordination among the plans. The different versions of the plans are held by all principal maintaining/operating agencies.

⁸ The CB Wizard Alert System device continuously broadcasts a warning message over Citizens Band (CB) radio to alert approaching drivers of a work zone or other roadway conditions. More information regarding the CB Wizard Alert System is available online at <http://ops.fhwa.dot.gov/wz/workshops/accessible/Maze.htm>.

⁹ More information regarding the North Carolina incident management program is available from the NCDOT or online at <http://www.ncsmartlink.org/incident>

To date, the I-40 contraflow plan has not been implemented, so no changes based on experience have been instituted. However, the NCDOT has executed a research project to do a traffic analysis on the plan and to recommend improvements to the plan. The research project is expected to be complete in January 2006.

7. South Carolina Implementation Experiences

South Carolina has documented several contraflow plans, including those for Interstate 26 (I-26) used for Charleston evacuations, U.S. Highway 278 used in Hilton Head Island evacuations; and U.S. Highway 501 used in evacuating the Myrtle Beach area. Each of these plans was developed in response to their supporting role of Emergency Support Function (ESF) 16, which is entitled Emergency Traffic Management.

The plan for I-26 was developed post-Hurricane Hugo, which struck in September 1989, but prior to Hurricane Floyd. The I-26 contraflow plan starts at Interstate 526 (I-526) on the north side of Charleston, with the next several interchanges designed to load the contraflow side. The plan ends at Interstate 77 (I-77) in Columbia using a one-lane ramp that is “coned” to allow two lanes of travel in this situation. The termination of the contraflow operation at the I-77 interchange forces all regular-side traffic off I-26 onto I-77, blocking all other movement access with cones.

There are other practices that South Carolina has implemented to support I-26 contraflow operations, including the use of drums and barricades at interchanges to restrict ingress/egress to and from the contraflow side, and to allow motorists from the contraflow side to exit for fuel, etc., at several interchanges. The South Carolina Department of Transportation (SCDOT) has developed a traffic control plan for every contraflow-affected interchange on I-26, detailing the placement of barrels, barricades, and personnel. While the SCDOT has considered the use of barrier gates to reduce manpower needs, there is concerned that, without human enforcement, traffic may bypass the gate.

The plan for U.S. Highway 278 from Hilton Head Island starts on the island at an interchange for the Cross Island Parkway. The route heads northwest onto the mainland to South Carolina (SC) State Road 170, where contraflow traffic must exit using a one-lane ramp. This plan is not a full contraflow, rather, it is a three-lane contraflow procedure, since U.S. Highway 278 is the only route connecting the island to the mainland. A full, four-lane contraflow plan has been developed for use only if extreme conditions dictate. This plan includes furnishing all surface routes with signs at major intersections. Plan provisions are reviewed annually.

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The plan for U.S. Highway 501 starts at its intersection with SC 22. Both U.S. Highway 501 and SC 22 are the primary routes for traffic traveling to and from the Myrtle Beach area. At the U.S. Highway 501/SC 22 intersection, U.S. Highway 501 becomes a contraflow in the northwest direction and continues to the Marion Bypass. This was implemented in advance of Hurricane Charley in 2004 and was conducted during nighttime conditions, with positive operational results.

All of the South Carolina contraflow plans are supported by several additional practices. One of the most important exercises is the SCDOT tabletop/field practice every year, where one of the routes is selected for actual field deployment. Other practices include:

- Use of portable HAR devices
- Use of flip-down static signage to advise contraflow motorists of approaching exits
- Use of incident/motorist response vehicles and wreckers to keep traffic flowing
- Use of painted exit numbers on interchanges to assist aerial surveillance activities
- Assessment of contraflow operations by CCTV cameras in Charleston and on U.S. Highway 278
- Use of logistics management software that acts as a task checklist program within the SCDOT
- Use of one set of counters on all routes to assess traffic volumes and flow¹⁰

Communication with portable VMS devices is supported using satellite-based networks to avoid dependency on cellular telephone technology, which has proven unreliable before, during, and after hurricane events. South Carolina emergency management operations also provide a hurricane guide that is distributed in newspapers on the first weekend of hurricane season. The guide includes shelter and evacuation route information. South Carolina's state highway map also shows evacuation routes and evacuation information. The Governor also completes a season-beginning coastal tour that provides media opportunities to raise awareness of hurricane preparedness.

¹⁰ The traffic volumes and flow data are available to the public online at <http://www.scdot.org/>.

8. Texas Implementation Experiences

Before the 2005 hurricane season, Texas had one planned contraflow route along Interstate 37 (I-37) from Corpus Christi to San Antonio. However, after the 2005 hurricane season and the experience gained from Hurricane Rita's landfall in the Beaumont/Port Arthur area, it became apparent that other roadways — namely, I-10 and I-45 — should have contraflow routes developed. This was due in part to concerns raised by Houston Mayor Bill White, who joined Gov. Rick Perry to order an evacuation of that city and the coastal communities to the south prior to Rita's landfall. An estimated 3 million Texans responded and fled their homes.

Previously, I-10 was not considered a candidate for an evacuation route because its eastern segment (between Beaumont/Port Arthur and Houston) doesn't remove traffic from the threatened coastal areas. In addition, Houston was not anticipated to be a candidate for evacuation. However, due to the varying landfall predictions for Hurricane Rita, an I-10 contraflow was ordered westbound from Houston to Seguin, near San Antonio. The contraflow operation began at the west end of the six-lane section extending from Houston and ending near Seguin. Contraflow operations occurred in both daytime and nighttime hours, and worked reasonably well under both scenarios.

Interstate 45 (I-45) was another route where lanes were reversed. The beginning point was in the Houston suburbs, just south of Conroe, which is north of where the dedicated, barrier-separated high-occupancy vehicle (HOV) lane ends. The end point was initially at the Buffalo interchange, but was quickly revised northward to Ennis, which is approximately 50 miles south of Dallas. This route crossed three different districts when in operation, including Houston, Bryan, and Dallas, all of which were involved in the operation.

Other routes, such as U.S. Highways 69 and 96, originate in the Beaumont/Port Arthur area and end up "self-contraflowing." In other words, evacuating traffic made the routes function as one-way northbound contraflow roadways of their own accord. While this scenario is to be avoided at all costs, the Texas Department of Transportation (TxDOT) indicated that these roadways operated reasonably well with just a few accidents and no catastrophic crashes.

The I-37 evacuation plan starts out as a shoulder-use plan that is intended for implementation 36 hours in advance of storm landfall. The plan calls for transition to a full contraflow operation as evacuation traffic increases. The intent is to respond to evacuating traffic needs with a less intense response, such as the use of the shoulder on the regular northbound side of the road, than a full contraflow operation, if circumstances allow. The shoulder-use plan starts out using the wide inside shoulder, shifts to the wide outside shoulder at the State Highway (SH) 77 interchange, which continues for the duration of the plan as I-37 heads northwest to San Antonio.

Part of the plan calls for restriping I-37 at the SH 77 interchange to provide motorists with positive direction for the lane shift required to transition from the left-side shoulder to the right-side shoulder. The TxDOT has restriped the northbound lanes to make a wider shoulder for hurricane evacuation use and also has static signage installed at the merge point of all entrance ramps. The signs have diagrams to indicate whether the shoulder is a travel lane.

Immediately north of the SH 77 interchange, the full contraflow plan has a crossover point that is only a single lane. The contraflow operation then proceeds to SH 72. The current operational concept continues use of the shoulder lane during full contraflow operation. There are mixed opinions within the TxDOT concerning the use of roadway shoulders during contraflow operations. The Texas Department of Public Safety has expressed concerns related to the full contraflow plan due to the resource requirements, but supports the shoulder-use plan.

Evacuation plan operations are supported by other practices, such as the use of Houston TranStar CCTV cameras to monitor the progress on Interstates 10 and 45. Closed-circuit television images are also available on a TranStar Web site, thereby providing information to motorists and officials elsewhere in the state. A media room in Austin is operated throughout hurricane evacuation situations to disseminate information. Portable VMS devices are used for the I-37 route, as well as courtesy patrols to assist motorists during operations.

In Texas, plans are implemented based on local agency recommendations to the Governor, who then orders the contraflow operation. Interagency coordination occurs through teleconferences during the operation. The I-37 contraflow, which is the only documented plan, is intended to be implemented 36 hours before a storm's landfall. It calls for leaving equipment and materials on the roadway until after the storm, but the TxDOT utilizes anchors to keep materials in place. Other contraflow operations, such as those for Interstates 10 and 45, do not have documented plans at this time, but they are under development. The TxDOT will establish start and end times for those routes currently being developed.

9. Virginia Implementation Experiences

The Virginia Department of Transportation (VDOT) has developed a contraflow plan for the Hampton Roads area (southeastern Virginia, including the cities of Newport News, Norfolk, and Virginia Beach) as part of an overall evacuation plan. As described by the VDOT, the Hampton Roads area is a "cul-de-sac" with I-64, which runs between Hampton Roads and Richmond, as the only limited-access route serving the area. Two other surface routes, U.S. Highway 460, which has high truck traffic, and U.S. Highway 58, both of which are approximate east-west routes, are also designated evacuation routes; neither of these two roads has contraflow operations planned for it.

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The regional evacuation plan Virginia developed is staged in two phases that are implemented before contraflow operations begin. Contraflow operations are described as being Phase 3. The first two phases are planned to evacuate the areas most vulnerable to flooding. Phase 1 covers the southern part of Hampton and north Virginia Beach. Phase 2 evacuates the next most vulnerable area, including Chesapeake.

After Phases 1 and 2 have been implemented, the plan calls for the consideration of Phase 3 contraflow operations on I-64. This contraflow route runs northwest from just south of the Hampton Roads Bridge-Tunnel on I-64 and continues approximately 80 miles to Richmond, where the plan terminates at the I-295/I-64 interchange on the east side of the city. Regular-flow traffic is forced to exit, but may choose either I-295 northbound or southbound. A paved crossover immediately downstream of the exits is used to transition contraflow traffic back onto the regular-flow lanes of westbound I-64.

This interchange was chosen as the ending point because of the considerable capacity on I-295 there. I-295 has four northbound lanes north of the interchange and three southbound lanes south of the interchange. I-295 narrows to two lanes farther south before the I-95 interchange. I-295 was intentionally widened to provide additional storage capacity for evacuation situations. The principal concern VDOT expressed is that the interchanges of I-295 and I-64 with I-95 will still experience congestion during evacuations because it is expected that the general public will also use I-95 as a means to evacuate. This will cause a backup at the I-295 interchange.

There are two exits on the contraflow part of I-64 where traffic can exit the contraflow side; a third exit is desired and a suitable candidate is being identified. A concern about the contraflow operation is that there is only one dedicated loading point: a single, two-lane paved crossover on the south side of the Hampton Roads Bridge-Tunnel. This crossover and another similar crossover on the north side of the bridge-tunnel were originally constructed to accommodate emergencies there. These incidents, which happen less than five times per year, can require closing one of the two tunnel tubes and running bidirectional traffic in the unaffected tube. The tunnel part of the bridge-tunnel, with two narrow lanes in each direction and no shoulders, acts as a capacity constraint for traffic traveling from the south side to the north side.

The 4th View Avenue interchange north/westbound entrance is the only loading point for the regular flow side south of the bridge-tunnel. All regular flow entrance lanes are open to allow traffic evacuating Hampton and Newport News to enter the regular flow side of I-64. VDOT would like another crossover on I-64 north/westbound in the vicinity of the Jefferson Road interchange (near the north end of the Newport News urban area, where there is a reduction from four lanes to two). This new crossover would allow VDOT to shift traffic from the regular-flow side to the contraflow side to attempt to equalize traffic volumes and manage congestion. There has also been discussion of creating an additional contraflow access/crossover on I-664 (which intersects I-64 north of the bridge-tunnel), but VDOT is concerned that this will allow entering traffic to overload I-64 instead of motorists using the two United States routes heading west out of the region.

The VDOT has implemented several practices in support of the contraflow operations. The principal outreach effort includes a color brochure developed in partnership with the Virginia Department of Emergency Management (VDEM). This literature is placed in major home improvement stores and will be available in grocery stores in the future. TV stations have also been active in distributing the brochure. In 2005, VDOT hosted an on-line hurricane forum where they offered a free mail-out from the Web site for all who requested it and received hundreds of requests. Local phone books also have pages summarizing evacuation information; it is intended that these pages be torn out and taken to provide basic evacuation guidance for those that are not year-round residents.

Other practices that are used in Virginia to support contraflow operations are the regional legacy ITS deployments and the installation of barrier gates, which is underway. The VDOT has ITS devices (CCTV cameras, DMS, and vehicle detection devices) on the south and north sides of the bridge-tunnel on I-64 and up to the I-664 interchange. Portable VMS are deployed as part of the contraflow plan to indicate the two places where traffic can exit the contraflow side. VDOT has a project underway to install 168 gates on the contraflow side of I-64 (and also south of the contraflow section to manage entering traffic). This gate installation effort had been planned since before Hurricane Floyd (1999), but did not gain support until recently when evacuation-oriented concerns took priority over aesthetic concerns that had made the gates undesirable.

The evacuation plans have been “tabletop” implemented, but have not been implemented in the field. In Virginia, the Governor makes the decision to implement the contraflow plans and the VDEM is responsible for the evacuation itself. The planned time to implement the contraflow operation is six hours. The contraflow is intended to run only during daylight hours, with setup occurring during predawn hours, and is anticipated to last one day.

10. Contraflow in Germany

Perhaps the most highly advanced and automated contraflow implementation is installed on a freeway in Hanover, Germany. This reverse-lane plan, known locally as the “Tidal Flow System”, is designed for rapid and relatively frequent contraflow of the freeway in response to scheduled events that generate large volumes of traffic.

The Tidal Flow System switches the travel direction on a 16-kilometer (about 10 miles) segment of the highway. The changeover is performed in 20 minutes and requires only six personnel to execute. Using numerous variable message signs and lane control signals, this semi-automatic system, designed by Siemens, is able to reverse at least four lanes (six lanes for the segments when there are shoulders). The implementation of this semi-automatic system allowed a dramatic reduction from 350 personnel required to only six using the following practices:

1. At principal interchanges there are DMS, horizontal swing barriers (gates), and traffic signal-based controls.
2. Additional DMS are used to manage opening of the shoulders.
3. While operating traffic on shoulders, the system uses a combination of dynamic traffic signs and internally illuminated stop lines.
4. At ramp terminal/interchanges, a traffic signal management system is used to assign the traffic on the interstate.
5. Other ITS or traffic management components include pneumatically raised and lowered tubular lane markers/delineators and illuminated raised pavement markers used to create a variable pavement stripe.

Other equipment and components used include signs on bridges, lane control signals, fiber optic displays for variable speed limits, CCTV cameras, and additional traffic information broadcast through the European Radio Data System network.

11. Conclusion

Numerous best practices are evident in the states' contraflow plan summaries. Common to all states are the selection of the most appropriate freeways for contraflow, careful planning of route beginning and end points, and proper management of contraflow operations. The plans are carried out using trained personnel who have the necessary equipment and technology available to them. Each plan relies on interagency coordination for effective oversight of contraflow planning and execution within the broader context of community hurricane response and public safety. The state departments of transportation and other agency colleagues also strive to assess performance and make improvements in an ongoing effort to have contraflow operations function more efficiently and safely.

The next document in this series of reports will itemize and describe the various best practices for contraflow operations. The pros and cons relating to each best practice and their potential application will also be presented.