Technical Memorandum 2

Traffic Incident Management

Contraflow Practice Assessments and Use Recommendations

April 7, 2006
Version 3

Prepared for:

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DOCUMENT CONTROL PANEL		
File Name:	*Technical Memorandum – Traffic Incident Management – Contraflow Practice Assessment and Use Recommendations*	
File Location:	W:\ITS Program\ITS GC\TWO60-Contraflow\TechMemo2\060406 TWO60 TM2 V3.pdf	
Deliverable Number:	N / A	
Version Number:	3	
	Name	**Date**
Created By:	John Hibbard, PBS&J	February 17, 2006
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Table of Contents

List of Figures ..... **iv**

List of Acronyms ..... **v**

1. Introduction **1**

2. Roadway Geometry and Access Management **2**

2.1 High-capacity Starting Points ***2***
2.1.1 Description 2
2.1.2 Application Locations 2
2.1.3 Assessment 3
2.1.4 Locations Recommended for Application 3
2.1.5 Unit Cost 4

2.2 Intermediate Crossovers ***5***
2.2.1 Description 5
2.2.2 Application Locations 5
2.2.3 Assessment 5
2.2.4 Locations Recommended for Application 7
2.2.5 Unit Cost 7

2.3 High-capacity Terminations ***8***
2.3.1 Description 8
2.3.2 Application Locations 8
2.3.3 Assessment 9
2.3.4 Locations Recommended for Application 9
2.3.5 Unit Cost 10

2.4 Direct Entry / Exit at Interchanges ***11***
2.4.1 Description 11
2.4.2 Application Locations 11
2.4.3 Assessment 11
2.4.3.1 Ramp Terminal Intersections *12*
2.4.3.2 On-ramp Entrances *12*
2.4.3.3 Two-lane Ramps *14*
2.4.4 Locations Recommended for Application 16
2.4.5 Unit Cost 16

2.5 Drop-gate Ramp Closures 17
2.5.1 Description..... 17
2.5.2 Application Locations..... 17
2.5.3 Assessment 17
2.5.4 Locations Recommended for Application..... 18
2.5.5 Unit Cost..... 18

2.6 Shoulder Lane Use 18
2.6.1 Description..... 18
2.6.2 Application Locations..... 18
2.6.3 Assessment 19
2.6.4 Locations Recommended for Application..... 20

2.7 New Contraflow Plans 20
2.7.1 Locations Recommended for Application..... 20

3. Motorist Information 21

3.1 Highway Advisory Radio 21
3.1.1 Description..... 21
3.1.2 Application Locations..... 21
3.1.3 Assessment 21
3.1.4 Locations Recommended for Application..... 22
3.1.5 Unit Cost..... 22

3.2 CB Wizard Alert System..... 22
3.2.1 Description..... 22
3.2.2 Application Locations..... 23
3.2.3 Assessment 23
3.2.4 Locations Recommended for Application..... 23
3.2.5 Unit Cost..... 23

3.3 Static Traffic Signs 23
3.3.1 Description..... 23
3.3.2 Application Locations..... 23
3.3.3 Assessment 24
3.3.4 Locations Recommended for Application..... 24
3.3.5 Unit Cost..... 24

4. Public Outreach 25

5. Plans Preparation 26

6. Miscellaneous Practices 27

7. Contraflow Operations with Future ITS Development 28

List of Figures

Figure 2.1 - Parallel Exit Lane 12

Figure 2.2 – Tapered Exit Lane 13

Figure 2.3 – Parallel Exit Lane Used as an Entrance Lane 13

Figure 2.4 – Tapered Exit Lane Used as an Entrance Lane 14

Figure 2.5 – Normal Two-lane Off-ramp 14

Figure 2.6 – Two-lane Off-ramp Used as an Entrance Ramp 14

Figure 2.7 – Normal Two-lane On-ramp 15

Figure 2.8 – Two-lane On-ramp Used as an Exit Lane 15

List of Acronyms

ALDOT ..... Alabama Department of Transportation
AVI ..... Automatic Vehicle Identification
CB ..... Citizens Band
CCTV ..... Closed-circuit Television
CR ..... County Road
DMS ..... Dynamic Message Sign
FDOT ..... Florida Department of Transportation
FHP ..... Florida Highway Patrol
FHWA ..... Federal Highway Administration
GDOT ..... Georgia Department of Transportation
HAR ..... Highway Advisory Radio
ITS ..... Intelligent Transportation System
mph ..... Miles per Hour
MUTCD ..... *Manual on Uniform Traffic Control Devices*
NCDOT ..... North Carolina Department of Transportation
SCDOT ..... South Carolina Department of Transportation
SR ..... State Road
TEOO ..... Traffic Engineering and Operations Office
TxDOT ..... Texas Department of Transportation
U.S. ..... United States
VDOT ..... Virginia Department of Transportation
VMS ..... Variable Message Sign

1. Introduction

Because of the increased hurricane activity experienced in the 2004 and 2005 seasons and indications that this level of 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 urban expressways. In connection with this project, the Florida Department of Transportation (FDOT) Traffic Engineering and Operations Office (TEOO) researched other states' experiences during recent hurricanes; the contraflow lessons learned; and best practices in planning and implementing these types of reverse-flow or one-way operations. The objective was to identify and examine the operations that would guide Florida in the development of route and infrastructure improvements plans.

In this technical memorandum, the project team assessed various contraflow practices from other states and evaluated whether they should be incorporated in Florida's plans. Potential locations on the highway system where these practices or improvements should be made were also examined. The cost anticipated to implement each practice is included at the end of the assessment.

[1] *Technical Memorandum – Contraflow Plan for the Florida Intrastate Highway System* (Version 1, June 2005). Available online at http://floridaits.com/Contraflow.htm.

2. Roadway Geometry and Access Management

This section assesses the practices associated with the roadway geometry and access management aspect of contraflow operations. Contraflow plans normally keep the on-ramps and off-ramps open on the regular-flow side. This section will focus on access management for the contraflow side. The key issues presented include access management at the beginning and ending of contraflow lanes, and the issues associated with access management — specifically, permitting direct entry to and exit from contraflow lanes.

2.1 High-capacity Starting Points

2.1.1 Description

Contraflow routes operate most efficiently where ample capacity allows traffic to fully utilize the contraflow (and regular-flow) lanes.

2.1.2 Application Locations

Florida – The Interstate 10 (I-10) contraflow route starts at the Interstate 295 (I-295) interchange in Jacksonville. The two regular-flow westbound lanes are directed to the two contraflow lanes using a two-lane crossover. The two ramps from northbound and southbound I-295 load traffic to the two regular-flow westbound I-10 lanes.

The State Road (SR) 528 contraflow route starts from the SR 520 interchange. The two contraflow lanes and the two regular-flow lanes are loaded with vehicles from four lanes. A one-lane on-ramp from northbound SR 520 and a one-lane crossover from the regular-flow lanes load vehicles on the two contraflow lanes. The remaining regular-flow lane and a one-lane on-ramp from southbound SR 520 load vehicles on the two regular-flow lanes.

Georgia – The Interstate 16 (I-16) plan that evacuates the southeastern Georgia coast begins immediately west of Savannah with two single-lane, high-speed crossovers that load traffic on the contraflow side.

South Carolina – The Interstate 26 (I-26) plan that evacuates the Charleston area begins north of Interstate 526 (I-526) with multiple single-lane entry points.

2.1.3 Assessment

Contraflow plans stand the best chance of working well, both from the capacity and speed perspectives, if they can start at a freeway-to-freeway interchange where the highway system has ample capacity available to allow traffic to fully load both the contraflow and regular-flow lanes. This goal is frequently achieved using a two-lane crossover on the contraflow highway to send all regular-flow traffic to the contraflow lanes prior to entering the interchange area. The empty regular-flow lanes are then loaded with vehicles from the regular-flow entrance ramps to the crossing arterial or freeway.

2.1.4 Locations Recommended for Application

Florida's Turnpike – The contraflow route for Florida's Turnpike begins at the SR 70 interchange in Fort Pierce. The two northbound regular-flow lanes are first widened to a three-lane cross section. The two inside lanes are directed to the two contraflow lanes using a two-lane crossover. The northbound right lane is dedicated to feeding traffic to the two regular-flow lanes. Since there are only two lanes to load traffic on the two contraflow lanes and the two regular-flow lanes, the contraflow and regular-flow lanes would probably not be fully utilized at the contraflow beginning point.

As downstream interchanges are configured to allow traffic to enter only the regular-flow side of Florida's Turnpike, northbound traffic approaching the contraflow crossover should be directed to the contraflow side as much as possible, providing the most capacity to the regular-flow entering traffic.

Consideration should be given to relocating the crossover at the contraflow route's starting point to south of the SR 70 interchange. This would provide entering traffic from SR 70 a better opportunity to get in the northbound regular-flow lanes.

Interstate 4 – The Interstate 4 (I-4) contraflow route starts at the Interstate 275 (I-275) interchange in Tampa. The current plans keep the ramps from I-275 open to allow traffic from I-275 to enter the I-4 regular-flow lanes. The plans then use a southbound I-275 ramp to load traffic from a local street to the I-4 contraflow lanes. Because a local street has limited capacity, the two contraflow lanes would probably not be fully utilized in this plan.

It has been noted that FDOT District 7 is aware of this capacity problem at the I-4 contraflow starting point. The plans are being revised to address this issue.

Alligator Alley – The Interstate 75 (I-75) Alligator Alley eastbound contraflow route starts at the SR 951 interchange near Naples. The plan uses a direct entry to load traffic on the contraflow lanes from an existing one-lane ramp. Since there is only one lane to feed two contraflow lanes, the contraflow lanes would not be fully utilized at the beginning point. However, this underutilization issue may not be a problem because the plan allows direct entry to the contraflow lanes at all subsequent interchanges to increase utilization of those lanes.

As discussed in *Section 2.4*, a direct entry to the contraflow lanes is not recommended. An alternative is to use a two-lane crossover at the beginning point to send regular-flow traffic to the contraflow lanes, and then use the ramps to load traffic to the regular-flow lanes. The beginning point could be moved north to SR 80 at Fort Myers.

It is noted that the I-75 Alligator Alley contraflow plans show a crossover at the eastern end of the contraflow route for use in conjunction with a westbound contraflow operation. However, no plan has been developed for the westbound contraflow operation. Only the eastbound contraflow operation is discussed in this report when this set of plans is referenced.

2.1.5 Unit Cost

The following equipment and personnel will be required for starting contraflow operations at a major interchange:

- Two portable variable message signs (VMS) on the regular-flow lanes to warn motorists of the shifting lanes ahead
- Fifty cones and one Florida Highway Patrol (FHP) trooper to close the regular-flow lanes
- A two-lane, paved crossover from the regular-flow lanes to the contraflow lanes

The unit cost for the construction of a typical two-lane paved crossover is $130,000.

2.2 Intermediate Crossovers

2.2.1 Description

Crossovers are paved travel ways in the highway median that allow traffic to cross from the regular-flow lanes to the contraflow lanes, or vice versa. Intermediate crossovers placed on the contraflow section's mid-block will allow motorists to access either set of lanes.

2.2.2 Application Locations

Alabama – The Alabama Department of Transportation (ALDOT) has several crossovers along the Interstate 65 (I-65) contraflow route that allow traffic flow between regular lanes and contraflow lanes to be balanced. Note, however, that these intermediate crossovers have not been used in conjunction with a hurricane evacuation.

Florida – The I-4 contraflow plans provide an intermediate crossover at the I-75 interchange that allows traffic to change from the regular-flow lanes to the contraflow lanes.

Virginia – While the Virginia Department of Transportation's (VDOT) contraflow plan for Interstate 64 (I-64) does not have an intermediate crossover at present, the VDOT expressed an interest in creating such a crossover where I-64 experiences a double-lane drop and reduces westbound traffic from four to two through lanes. It is thought that this crossover would allow the VDOT to better balance evacuating traffic streams between the two sides of I-64.

2.2.3 Assessment

Intermediate crossovers allow motorists to enter or exit contraflow lanes at various locations within the contraflow section. Intermediate crossovers can be useful under the following circumstances:

- When regular flow and contraflow lanes have unbalanced utilization, intermediate crossovers can balance lane utilization if carefully and deliberately managed.
- When rest areas are not present on the freeway, intermediate crossovers can allow contraflow traffic to return to regular-flow lanes, and then exit to access gas, food, and rest stops.
- When there is a need for motorists from areas surrounding the contraflow section to enter the contraflow lanes, intermediate crossovers can allow those motorists to first enter the regular-flow lanes and then enter the contraflow lanes from intermediate crossovers.

- When arterials or freeways in the contraflow section have extra capacity that can be used to evacuate traffic, intermediate crossovers can allow motorists to first exit to regular-flow lanes, and then to arterials or freeways.

Rest areas, mainline toll plazas, or other facilities located between the through lanes could be utilized to provide intermediate crossover access between contraflow and regular-flow lanes. Examples include:

- The contraflow plans for Florida's Turnpike allow motorists to revert to regular-flow lanes from the contraflow lanes at service plazas and mainline toll plazas.
- The I-75 Alligator Alley contraflow from SR 951 to United States (U.S.) Highway 27 allows contraflow traffic to return to regular-flow lanes at the Miami Canal Rest Area.

Intermediate crossovers should not be placed at locations where the following conditions exist:

- Where the freeway is on a curve or at a hill that restricts the sight distance of the crossover
- Where the median is wide and there is a great difference in elevation between the regular-flow lanes and contraflow lanes
- Where the median is narrow with barrier walls
- Where the median has dense trees or topography restrictions, such as deep ditches
- Near an interchange merge or diverge

For crossovers from regular-flow lanes to contraflow lanes, the beginning of the crossover should be at least 4,000 feet from the closest on-ramp entrance to allow motorists sufficient time to change from the on-ramp side to the crossover side. Similarly, for crossovers from contraflow lanes to regular-flow lanes, the end of the crossover should be at least 4,000 feet from the closest off-ramp to allow motorists sufficient time to change from the crossover side to the off-ramp side.

Intermediate crossovers should be designed with consideration for the following:

- *Adequate design speed* – While the crossover's design speed does not necessarily need to coincide with the roadway's design speed, a design speed of 40 to 50 miles per hour (mph) is recommended to adequately address lower-volume times within the contraflow operation when speeds may increase.
- *Appropriate end treatments* – If the crossover requires the removal of existing guardrails or other median barrier treatments, appropriate end treatments must be incorporated into the crossover design.

- *Appropriate temporary barricades* – Intermediate crossovers typically require barricades to prevent undesired use of the crossover.
- *Appropriate traffic control* – Intermediate crossovers require significant traffic management oversight to be used effectively.

2.2.4 Locations Recommended for Application

This practice is not recommended for addition to any existing contraflow plans due to the lack of operational experience nationally and due to the level of traffic management commitment required for effective use.

Interstate 4 – The I-4 contraflow plans currently provide an intermediate crossover at the I-75 interchange to allow traffic to change from the regular-flow lanes to the contraflow lanes. The plans also provide a temporary slip ramp immediately downstream of the intermediate crossover to allow contraflow traffic to exit on I-75. If the intent of the intermediate crossover is to allow regular-flow traffic to exit on I-75, the intermediate crossover must be relocated to a minimum of 6,000 feet west/south of the I-75 interchange to allow motorists sufficient time to cross three lanes from the intermediate crossover side to the temporary slip ramp side.

2.2.5 Unit Cost

The following infrastructure and equipment will be required for intermediate crossovers:

- A 20-foot-wide crossover allowing one lane of traffic to be diverted to the opposite side
- A 350-foot deceleration distance at the beginning of the crossover, assuming a 40-mph speed limit in the contraflow lanes
- A 1,140-foot acceleration distance at the end of the crossover, assuming a 55-mph speed limit in the regular flow lanes
- A 64-foot-wide median
- Two portable VMS units to warn motorists of the upcoming crossover

Note that intermediate crossovers from the regular-flow side to the contraflow side would be less expensive because of shorter deceleration and acceleration distances. Such a crossover will need a 500-foot deceleration distance at the beginning and a 490-foot acceleration distance at the end, assuming a 40–mph speed limit on contraflow lanes and 55-mph speed limit on regular-flow lanes.

The unit cost for construction of a typical one-lane, paved intermediate crossover is $400,000.

2.3 High-capacity Terminations

2.3.1 Description

The critical part of a contraflow plan is the termination. Frequently, contraflow operations have significant backups due to poorly designed contraflow terminations. Consequently, a contraflow plan must end at a point where ample capacity prevents significant backups at the termination point. A secondary planning consideration is the ability of motorists leaving the contraflow route to find nearby lodging or local shelters, if needed.

2.3.2 Application Locations

Florida – The I-4 contraflow plans terminate at the World Drive interchange. The regular-flow lanes are directed to a two-lane ramp leading to SR 417 (Eastern Beltway). The contraflow lanes transition back to eastbound I-4 using a two-lane crossover.

The SR 528 contraflow plans terminate at the SR 417 interchange. The regular-flow lanes are directed to a two-lane ramp leading to northbound SR 417. The contraflow lanes are transitioned back to westbound SR 528 using a two-lane crossover located within a mainline toll plaza area.

The contraflow plan for Florida's Turnpike terminates at the SR 429 (Western Beltway) interchange in Ocoee. The regular-flow lanes are directed to a two-lane ramp that leads to northbound SR 429. The contraflow lanes are transitioned back to the northbound Turnpike through a two-lane crossover.

South Carolina – The I-26 contraflow plan ends at the Interstate 77 (I-77) interchange in Columbia. Similar to the operation described above, the I-26 westbound traffic is forced to exit on I-77 northbound, and the I-26 contraflow traffic transitions to I-26 westbound and continues toward Spartanburg.

Virginia – The I-64 contraflow plan terminates at the I-295 interchange on the east side of Richmond. The plan allows regular-flow traffic to exit either to I-295 northbound or southbound, and allows contraflow traffic to transition back to the regular-flow lanes that continue to Richmond via a crossover.

2.3.3 Assessment

Most contraflow plans terminate at a major (i.e., system) interchange — that is, an interchange connecting two freeways. The regular-flow lanes are generally forced to exit on a two-lane ramp or, in cases where there are two exits, are directed to exit on the two ramps. This allows motorists to choose between the two exits. The contraflow lanes then transition back to the regular-flow lanes using a two-lane crossover. Preferably, the crossovers would be located within the interchange area, allowing the same interchange to be used to close the regular-flow lanes used for the contraflow operation.

Because contraflow operations are generally implemented on four-lane freeways (i.e., two lanes in each direction), it is crucial to end both the regular-flow and contraflow lanes at a two-lane termination point to avoid traffic congestion. Additionally, terminating points generally do not function at the full capacity of typical free-flow lanes due to the evacuation-oriented circumstances surrounding their use.

Terminating capacity is probably the most important reason used to explain why most contraflow plans are implemented on four-lane freeways, even though as many lanes as possible should be used during hurricane evacuations. If contraflow operations are implemented on freeways with more than four lanes — for example, a six-lane freeway — three lanes of terminating capacity will be needed at the end to direct the regular-flow traffic to the intersecting freeway. However, a three-lane ramp is rarely seen.

If capacity at the ending point can be handled properly, implementation of contraflow operations on freeways with more than two lanes in each direction could still be considered. An example of such a situation is when a six-lane freeway has two off-ramps leading to the two directions of the intersecting freeway, and at least one of them is a two-lane ramp. The three regular-flow lanes can be directed to the two off-ramps, and the three contraflow lanes can then be transitioned back to the regular-flow lanes using a three-lane crossover.

2.3.4 Locations Recommended for Application

Interstate 10 – The original I-10 contraflow plan started at I-295 in Jacksonville and ended at U.S. Highway 19 in Jefferson County. This plan had a capacity problem at the ending point. The two contraflow lanes were directed to a one-lane off-ramp leading to an at-grade ramp terminal intersection.

District 2 recently revised the I-10 contraflow plan to terminate at I-75. The revised plan also has a capacity problem at the termination point on the regular-flow side. The two regular-flow lanes are transitioned to a single lane before exiting to northbound I-75. The two contraflow lanes are then directed to the regular-flow lanes using a two-lane crossover located west of I-75. To remedy the capacity problem, the outside regular-flow lane could be directed to northbound I-75 and the inside regular-flow lane could be directed to southbound I-75.

Alligator Alley – The Alligator Alley contraflow plan for I-75 from SR 951 to U.S. Highway 27 has a capacity problem at the termination point. The two contraflow lanes are tapered to a one-lane crossover that merges with the regular-flow lanes.

An extension of the contraflow lanes further to the east of the Interstate 595 (I-595) interchange is the recommended remedy for this capacity problem. The two regular-flow lanes could be directed to a two-lane ramp leading in the northbound direction of Florida's Turnpike. The two contraflow lanes could then be transitioned back to two regular-flow lanes using a two-lane crossover.

The proposed I-75 contraflow plan for evacuating Collier and Lee counties northward is to have its northern end at the I-75/I-275 interchange in Tampa as described previously, which should provide an adequate terminating capacity to the greatest extent possible.

2.3.5 Unit Cost

The following equipment and personnel will be required for terminating contraflow lanes at a system interchange:

- Two portable VMS units on regular-flow lanes warning all motorists to exit
- One hundred cones and one FHP trooper to close the regular-flow lanes
- Two portable VMS units on the contraflow lanes warning motorists that the lane shifts ahead
- A two-lane crossover from the contraflow lanes to the regular-flow lanes
- Fifty cones and one FHP trooper to close the contraflow lanes

The unit cost for the construction of a typical two-lane paved crossover is $130,000.

2.4 Direct Entry / Exit at Interchanges

2.4.1 Description

Direct entry and exit at interchanges allows vehicles to enter or leave contraflow lanes directly from existing ramps at interchanges.

2.4.2 Application Locations

Alabama – The I-65 contraflow plans allow direct exits at all interchanges, but not direct entries.

Florida – The I-4 contraflow plan allows direct exit at six interchanges, including I-75, County Road (CR) 579, SR 39, County Line Road, and U.S. Highways 27 and 98. The plan also allows direct entry at three interchanges, including CR 579, SR 39, and County Line Road.

The I-10 contraflow plans allow direct exit at seven interchanges (i.e., U.S. Highways 301, 90, 441, 129, and 19; SR 121; and CR 257), but direct entry is not allowed.

The contraflow plan for I-75's Alligator Alley SR 951 east to U.S. Highway 27 allows direct entry and exit at all interchanges.

North Carolina – The I-40 contraflow plans allow direct entry and exit at all interchanges; however, the North Carolina Department of Transportation (NCDOT) may revise this practice to prohibit direct entry to the contraflow lanes.

South Carolina – The I-26 contraflow plans allow direct exit at several interchanges, and direct entry at the first several interchanges.

2.4.3 Assessment

Direct entry and exit at ramps could be useful in the following circumstances:

- When regular-flow and contraflow lanes have unbalanced utilization, direct entry/exit at ramps could help balance lane utilization.
- When rest areas are not provided on the freeway, direct exit at ramps will allow motorists in the contraflow lanes to obtain fuel, food, and rest stops. Direct entry would permit motorists to continue traveling on the contraflow side.
- When there is a need for motorists from areas surrounding the contraflow section to enter the contraflow lanes

- When arterials or freeways along the contraflow section have extra capacity that can be used to evacuate traffic, direct exit at ramps will allow motorists to access the arterials or freeways.

Due to the unusual nature of using a roadway in the opposite direction from its original design direction, a direct entry/exit at ramps poses a safety concern, particularly those noted in the following sections.

2.4.3.1 Ramp Terminal Intersections

Since permanent traffic control devices are placed facing the regular-flow direction, temporary traffic control devices will be required to control contraflow traffic.

If the ramp terminal intersection is controlled by stop signs, temporary stop signs and stop bars facing the contraflow direction will be required. Permanent signs that are not applicable, such as one-way signs or do-not-enter signs, should be covered during contraflow operations. An alternative is to replace these signs with “flip-down” signs that can be closed when not in use.

If the ramp terminal intersection is controlled by a traffic signal, temporary signal heads facing the contraflow direction should be provided, and signal heads no longer applicable should be covered or removed. However, since signal heads and phasing sequence are generally tied to the original intersection configuration, it might be difficult to alter the signal head configuration and phasing sequence in a timely manner. An alternative is to place the traffic signal in flashing operation and have a FHP trooper or law enforcement officer control traffic.

2.4.3.2 On-ramp Entrances

The on-ramp entrance to the contraflow lanes is the off-ramp exit from the regular-flow direction. As illustrated in the following, there are two types of off-ramp exit lanes: parallel and tapered. As shown in Figure 2.1, a parallel exit lane begins with a taper, followed by an added lane that is parallel to the mainline travel lanes. A tapered exit lane diverges from the outside mainline travel lane with a taper leading to the exit as depicted in Figure 2.2.

Figure 2.1 - Parallel Exit Lane

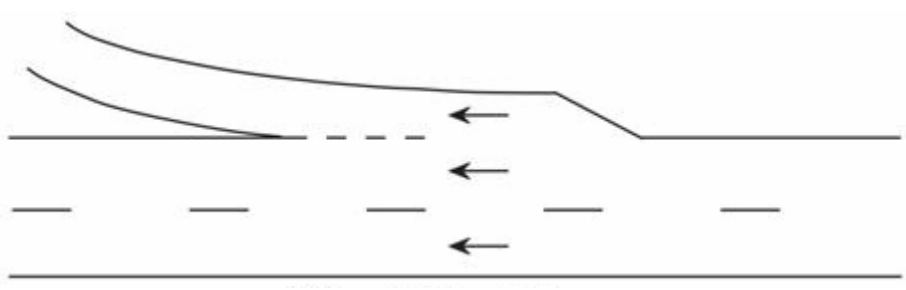


Figure 2.2 – Tapered Exit Lane

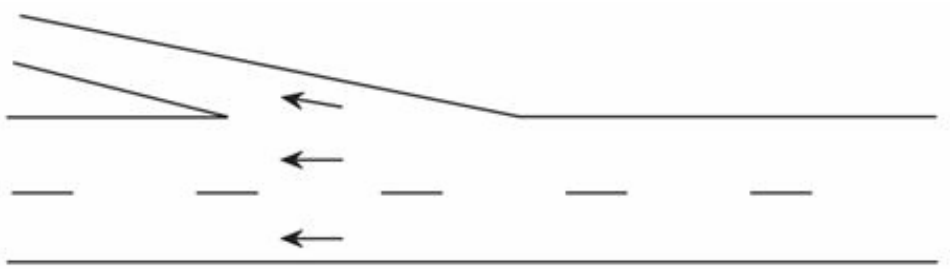
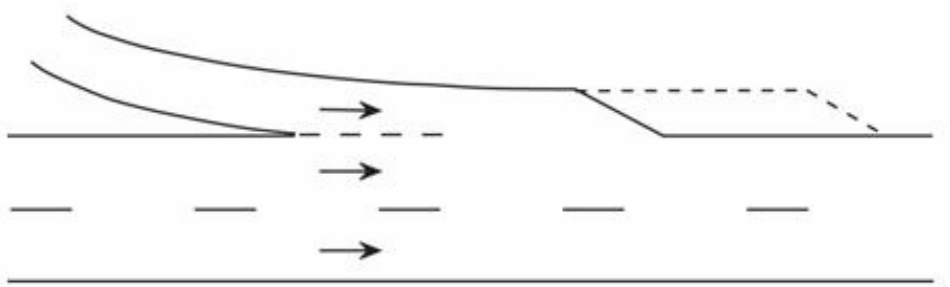


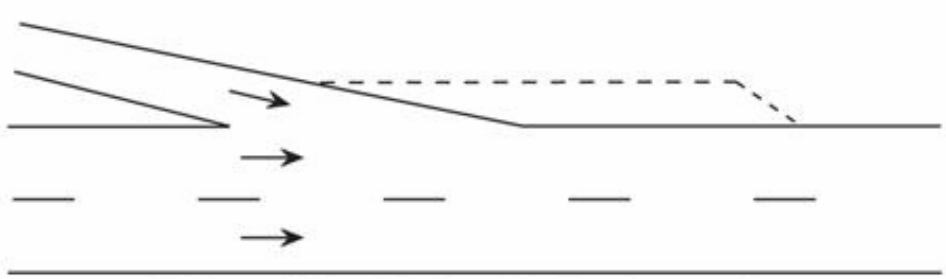
Figure 2.3 shows a parallel exit lane that can be used as a parallel entrance lane in most cases. Note that the acceleration distance may need to be lengthened. For example, if the regular-flow direction is posted with a 55-mph speed limit and is provided with a 530-foot deceleration distance, the deceleration distance is only good for a 40-mph speed in the contraflow direction. A longer acceleration distance will be needed if the contraflow lanes are posted with a speed limit higher than 40 mph. It should be noted that an increased acceleration distance is crucial to the entering traffic that will merge into the left lane, or higher speed traffic, of the contraflow lanes.

Figure 2.3 – Parallel Exit Lane Used as an Entrance Lane



As illustrated in Figure 2.4, when tapered off-ramps are present, they should be changed to parallel entrances when used as entrance lanes to the contraflow direction, since most drivers prefer parallel entrance lanes.

Figure 2.4 – Tapered Exit Lane Used as an Entrance Lane



2.4.3.3 Two-lane Ramps

As illustrated in Figure 2.5, two-lane off-ramps generally have a parallel exit lane plus an optional lane. As shown in Figure 2.6, the optional lane should be closed when the two-lane off-ramp is used as an entrance lane to the contraflow direction.

Figure 2.5 – Normal Two-lane Off-ramp

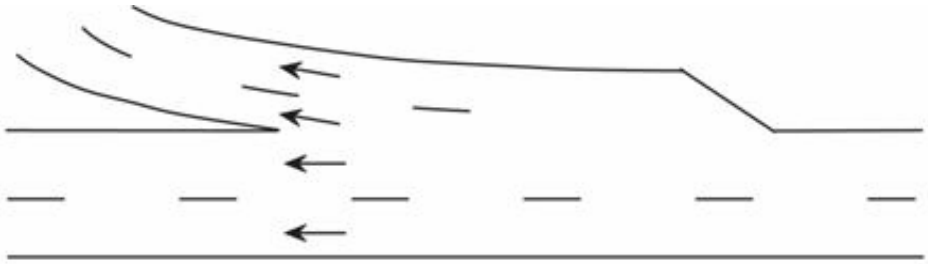
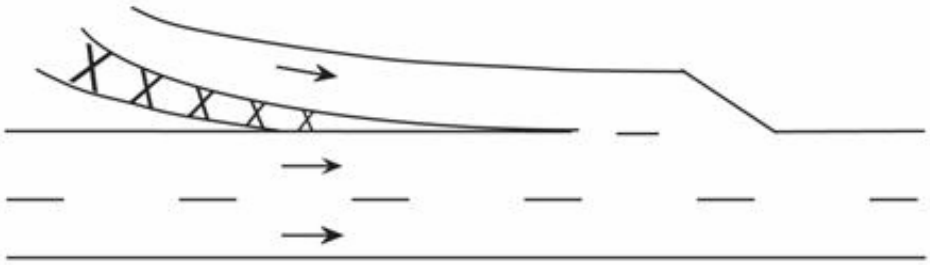


Figure 2.6 – Two-lane Off-ramp Used as an Entrance Ramp



Similarly, as illustrated in Figure 2.7, two-lane on-ramps generally have two parallel entrance lanes. The outside entrance lane should be closed when the two-lane on-ramp is used as an exit lane for the contraflow direction as illustrated in Figure 2.8.

Figure 2.7 – Normal Two-lane On-ramp

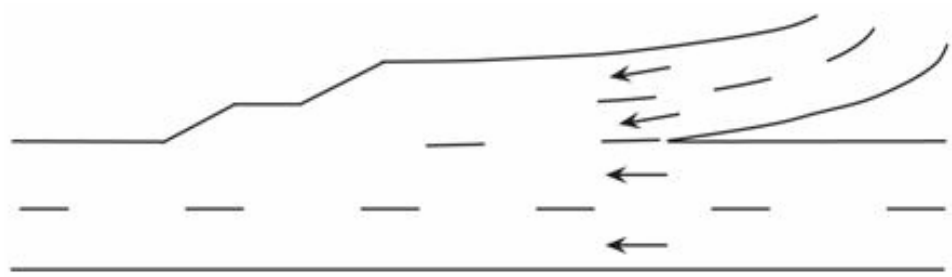
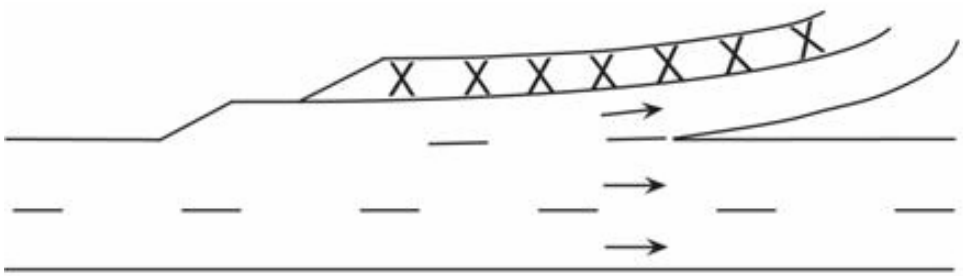


Figure 2.8 – Two-lane On-ramp Used as an Exit Lane



It should be noted that advance warning signs must be placed to alert motorists that exits are on the left side when a direct exit from contraflow lanes is allowed, since most motorists expect exits to be on the right side.

A direct entry/exit at ramps should not be utilized when the off-ramp exit lane has limited space that cannot be lengthened if a longer acceleration distance is needed based on the posted speed limit. Intermediate crossovers and direct entry/exit at ramps can be used interchangeably to achieve the same purposes. For example, when freeways do not have a longitudinal distance sufficient to provide intermediate crossovers, a direct entry/exit at ramps could be used as a substitute.

Since most on-ramp entrances can be used as exit ramps without difficulty, a direct exit from the contraflow lanes could be considered, as long as the ramp terminal intersections are properly controlled. This practice is especially useful because it allows contraflow traffic to access gas, food, or restroom facilities when service plazas are not present on freeways.

A direct entry to the contraflow lanes is generally undesirable because it requires entering traffic to merge into high-speed contraflow traffic (i.e., the left lane), an atypical maneuver for both streams of conflicting traffic. This practice would be even less desirable if the acceleration distance provided in the exit lane is inadequate based on the posted speed limit for the contraflow lanes.

2.4.4 Locations Recommended for Application

The contraflow plans for Interstates 4 and 10, and I-75's Alligator Alley from SR 951 to U.S. Highway 27 already allow direct exit from contraflow lanes. Florida's Turnpike does not need direct exits because service plazas are present to provide motorist services to both sides of the highway.

Direct exits, at least at key interchanges, could be considered for all contraflow plans.

2.4.5 Unit Cost

The following equipment and personnel will be required for direct exit from contraflow lanes:

- Two portable VMS units placed on the contraflow lanes before the interchange to give motorists advance warning of the direct exit
- One portable VMS unit placed on the contraflow lanes after the interchange to inform motorists of the highway number and distance to the next exit
- A law enforcement officer to direct traffic at the ramp terminal intersection

Direct exit from contraflow lanes does not generally require construction or modification of the ramp.

2.5 Drop-gate Ramp Closures

2.5.1 Description

This practice involves the use of drop gates to close exit and entrance ramps, instead of barricades and cones.

2.5.2 Application Locations

Georgia – The Georgia Department of Transportation (GDOT) installed hand-crank drop gates on all exit and entrance ramps along the I-16 contraflow route to restrict traffic from entering and exiting the contraflow lanes. In addition, the GDOT is installing similar gates on Interstates 75 and 95 for their interim contraflow plans on those routes. The GDOT is not expected to assign any personnel to the ramps with drop gates.

Virginia – The VDOT is installing drop gates on all exit and entrance ramps along the I-64 contraflow route to restrict traffic from entering and exiting the contraflow lanes. This includes guardrail installation as necessary to prevent motorists from driving around the gates. Through this installation, The VDOT is using these installations to reduce the time necessary for contraflow deployment and to decrease the personnel needed for operations.

2.5.3 Assessment

When direct entry/exit at ramps is not allowed for contraflow traffic, most states use barricades and cones to close exit and entrance ramps, and assign highway patrol or law enforcement officers to ensure ramp closures. Instead, this practice uses pre-installed drop gates to close the exit and entrance ramps.

The drop gates installed at exit and entrance ramps are similar to those used at highway-railroad at-grade crossings, except the drop gates are operated manually. Gate structures should be installed outside the clear zone to ensure safe ramp operations when the gates are not in use.

If wind resistance becomes a maintenance issue for the drop gates, an alternative concept would be to install swing-type gates that will remain parallel to the road surface whether open or closed.

The primary benefit of using drop gates is to reduce personnel and maintenance of traffic requirements for ramp closure sites. There are concerns, however, that motorists could still drive around the gates to make a wrong-way entry or exit when no highway patrol or law enforcement officers are present. These concerns are the principal reasons why Virginia is installing guardrails parallel to the ramps in conjunction with gate installation.

2.5.4 Locations Recommended for Application

This practice could be considered for all contraflow plans where the available traffic control manpower is limited. Use of drop gates with on-site law enforcement personnel is only recommended when manpower needs and setup time will be reduced due to their installation. However, operational experience with drop gates does not presently exist, and the experiences of those states that have implemented contraflow operations — none of which have drop gates — does not indicate a strong need for such devices.

2.5.5 Unit Cost

The following parameters are assumed in the unit cost calculations for using drop gates to close a ramp:

- Two drop gates per ramp, one near the ramp terminal intersection and one near the gore area of the ramp-freeway connection point
- A typical gate has a 36-foot arm, which covers a 16-foot-wide one-lane ramp, a 4-foot-wide left paved shoulder, and a 16-foot-wide right clear zone

The total anticipated cost is $5,000 per gate.

2.6 Shoulder Lane Use

2.6.1 Description

This practice uses the right paved shoulder as an additional travel lane to increase evacuating capacity.

2.6.2 Application Locations

Florida – The evacuation plan for the northbound portion of I-75 from Toledo Blade Boulevard in North Port to SR 681 uses the right shoulder in the northbound direction as one additional travel lane. The plans do not call for contraflow operations on the southbound side.

Texas – The Interstate 37 (I-37) evacuation plans use the left shoulder on the urban section of I-37 from SR 358 to U.S. Highway 77, and then transition to the right shoulder on the rural section of I-37 from U.S. Highway 77 to SR 72. Static signs were installed at all entrance ramp merge points to indicate whether the shoulder is in use as a hurricane evacuation lane or as a shoulder.

2.6.3 Assessment

Although paved shoulders in the regular-flow direction could be utilized as one extra lane in some circumstances, a cleanup of the shoulder should be performed prior to opening the shoulder to traffic. Various types of debris frequently accumulate on paved shoulders and some of the materials could puncture tires and cause damage to vehicles.

The left paved shoulder is usually 4 to 8 feet wide on four-lane freeways. The left shoulder generally should not be used as a travel lane because of its narrow width and because it is adjacent to the higher-speed travel lane.

The right paved shoulder is normally 10 feet wide on four-lane freeways, which is two feet narrower than typical travel lane width. The shoulder usually has a steeper cross slope than the travel lanes, and there may be uneven pavement near the edge of the through lanes because of different materials used for the shoulder pavement. Some paved shoulders have grooves ground into the pavement as a means of alerting motorists that have departed from the travel lane. Some Florida freeways also have motorist aid call boxes placed very close to the edge of the paved shoulder. For these reasons, speeds should be restricted when motorists are allowed to drive on the shoulder. Driving on the left paved shoulder in the contraflow direction should not be allowed because it traffic would be adjacent to the higher-speed travel lane of contraflow traffic.

When driving on the right paved shoulder is allowed, the entering traffic from on-ramps must be warned to stop at the merge point because the acceleration lane originally designated for entering traffic will be used by traffic driving on the shoulder.

Driving on the right paved shoulder should not be allowed under the following conditions:

- When rumble strips are present on the paved shoulder because the annoyance of the noise and vibration makes driving on the shoulder intolerable.

- When the paved shoulder width is less than 10 feet. These situations could occur near bridge structure that underpasses freeways or on bridge sections used to overpass freeways where the shoulder may not be normal.

2.6.4 Locations Recommended for Application

The information presented above, along with the information received at contraflow evacuation stakeholder meetings held throughout Florida in 2005 and the information received from the Texas Department of Transportation (TxDOT) in 2006, makes the case for a strong recommendation that shoulder use be discouraged for hurricane evacuation operations.

Later in this report, a proposed contraflow plan is presented for the area that includes the I-75 shoulder-use route in Charlotte County. This plan is presented as a more acceptable interstate evacuation concept than the shoulder-use plan.

2.7 New Contraflow Plans

Based on the contraflow plans' review conducted in 2005, as well as the activities performed under this project, three additional contraflow plans are recommended to provide more evacuating traffic capacity for southeast and southwest Florida, and the Tampa Bay area.

2.7.1 Locations Recommended for Application

The I-75 northbound shoulder-use evacuation plan, which begins at Toledo Blade Boulevard and continues to SR 681, is recommended for replacement with a northbound contraflow plan. It is also recommended that the north end of the plan be extended to the I-75/I-275 interchange at the southern side of Tampa Bay and the south end of the plan start at either the SR 681 interchange near Sarasota or the U.S. Highway 17 interchange at Port Charlotte, which is further south.

The I-75 Alligator Alley needs to have a westbound contraflow plan. The plan could start from the I-595 interchange with a two-lane crossover to direct regular-flow traffic to the contraflow lanes prior to entering the I-595 interchange. The ending point could be placed at the SR 80 interchange.

A new northbound contraflow plan for I-75 from I-275 in Tampa to I-10 in Lake City is recommended for development. The plan could start at the I-275 interchange with a two-lane crossover to direct regular-flow traffic to the contraflow lanes prior to entering the I-275 interchange, and a two-lane crossover within the I-10 interchange area to direct contraflow traffic back to the regular-flow lanes. The plan should have a subset plan to begin the contraflow operation at Florida's Turnpike if that route is contraflowed to its end at Wildwood.

3. Motorist Information

This section assesses the practices associated with guiding contraflow traffic. The practices will provide information to motorists and guide them to safely traverse the contraflow routes.

3.1 Highway Advisory Radio

3.1.1 Description

This practice places portable or permanent highway advisory radio (HAR) transmitters with preprogrammed messages to inform motorists of the contraflow operations.

3.1.2 Application Locations

The following states used HAR in their contraflow plans: Alabama, Georgia, North Carolina, and South Carolina.

3.1.3 Assessment

Highway advisory radio has an uneven history of effectiveness within the intelligent transportation system (ITS) toolbox. While some ITS deployments have used HAR extensively, others have not shared such widespread deployment, and others have abandoned HAR subsystems due to operational unevenness and inconsistency. However, HAR has tremendous operational flexibility that can be used as an advantage in evacuations and contraflow operations. Highway advisory radio systems can accommodate long messages and broadcast in multiple languages, whether as part of a single, bilingual broadcast or as part of two separately broadcast messages.

One drawback of HAR is that the motorist is required to take an action (i.e., tuning the radio to a specific station) to receive HAR information. In contraflow evacuations, motorists are “starved” for information, and so the likelihood that they will respond to the request for action (typically conveyed by static signage) is greatly increased.

Highway advisory radio could be placed on freeways near the beginning of the contraflow section to warn motorists of the contraflow operations ahead. It could also be placed in the middle of the contraflow section to provide motorists with additional "confirmation" information and evacuation information as it is learned. By its nature, an evacuation scenario causes considerable curiosity and concern among those evacuating. A HAR system can help mitigate such concerns. Highway advisory radio should also be placed near the end of a contraflow route to provide information to motorists on choices they have to make concerning routing, if choices are available. At a minimum, the preprogrammed messages should include the dates and times of the contraflow operations, and the entrance and exit points for the contraflow routes. Message sets should be developed as part of the route planning and design process to speed implementation when needed and to ensure consistent message delivery.

While highly dependent on terrain and geological factors, HAR generally has reliable coverage up to three miles from the transmitter site. Transmitters are normally placed on high ground to ensure minimum obstruction of the transmission. The HAR equipment should be placed outside of the clear zone to ensure safe operation of the highway. Candidate locations are within interchanges, between the mainline, at cross routes, and on ramps. Permanent locations are strongly encouraged due to the need for HAR installations to have well-designed and well-installed grounding. Temporary HAR sites cannot have the ground field required for consistent, effective HAR transmission.

3.1.4 Locations Recommended for Application

A HAR system is already operating on Florida's Turnpike and is recommended for the I-4, I-10, I-75, and SR 528 contraflow routes.

3.1.5 Unit Cost

The unit cost is $80,000.

3.2 CB Wizard Alert System

3.2.1 Description

The CB Wizard Alert System is similar to HAR except that it is a proprietary product designed to communicate with drivers whose vehicles are equipped with a citizens band (CB) radio. The CB Wizard Alert System continuously broadcasts a warning message over CB radio to alert drivers of roadway conditions ahead. Because many long-haul trucks are equipped with a CB radio, this system sometimes is regarded as a communications system just for trucks.

3.2.2 Application Locations

Only the states of North Carolina and South Carolina used the CB Wizard Alert System in their contraflow plans.

3.2.3 Assessment

Unlike HAR, which reaches all drivers, the CB Wizard Alert System primarily reaches truck drivers. The CB Wizard can be useful when contraflow plans place special requirements on trucks, such as requiring them to use regular-flow lanes only. Under such circumstances, trucks must be warned not to enter the contraflow lanes.

3.2.4 Locations Recommended for Application

The CB Wizard Alert System is recommended for the I-4 and I-75 contraflow routes due to the significant truck traffic present on those roadways.

3.2.5 Unit Cost

The unit cost is $10,000.

3.3 Static Traffic Signs

3.3.1 Description

Traffic signs are needed to provide advance warnings to motorists before the contraflow section and to guide them as they travel the contraflow section, including guide signage in advance of exits from the contraflow side. Most contraflow plans use temporary traffic signs, deployed at the time of contraflow plan implementation and removed afterwards, but some plans use static traffic signs. Static signage also includes “flip-down” signs that can display two messages — or prevent the display of a message that is no longer needed.

3.3.2 Application Locations

Alabama, Mississippi, Louisiana, South Carolina, and Texas use static traffic signs in their contraflow plans.

3.3.3 Assessment

When traffic signs are installed permanently for contraflow operations, they must not be visible to traffic in the regular-flow direction. Most states use flip-down signs to hide the sign display when they are not in use. The placement of traffic signs must comply with the Federal Highway Administration (FHWA) *Manual on Uniform Traffic Control Devices* (*MUTCD*).[2]

3.3.4 Locations Recommended for Application

Flip-down signs would be appropriate for use on any Florida contraflow routes where a permanently mounted warning or guide message is needed.

3.3.5 Unit Cost

The unit cost for flip-down signs varies depending on the size and installation of the sign, such as a sign standing alone or being attached to the back of an existing sign. The unit cost is $1,500, and assumes a standalone 4-foot-by-4-foot sign.

[2] Federal Highway Administration, *Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways – 2003 Edition* (including Revision 1 dated November 2004). More information regarding the FHWA's current *MUTCD* is available online at http://mutcd.fhwa.dot.gov/.

4. Public Outreach

Both prior to and following hurricane events, the public must be able to receive accurate and timely information so they can evacuate from and return to the affected areas safely and quickly. The following is a summary of the practices that have been applied by other states that were beneficial.

- Place posters, leaflets, or other printed materials at hotels, restaurants, or rest areas for distribution. It should be noted, however, that this practice would be expensive.
- Set up a Web site that provides the public with hurricane evacuation information online.
- Provide contraflow information to the news media, including radio and television stations; newspapers; and other print media. Supplement this effort using HAR and the 511 advanced traveler information service.
- Display contraflow information on existing dynamic message signs (DMS) locations along highways.
- Print a hurricane guide that is distributed in newspapers on the first weekend of hurricane season. Make sure the guide provides hurricane shelter locations and evacuation information, including which highways to use, what items to bring, and what to expect along contraflow routes in the way of fuel, food, and travel information.
- Use the existing public emergency alert system, which is generally used for broadcasts during emergencies, to transmit information about the contraflow routes and current operations.
- Set up a centralized media room to handle all press contacts during the contraflow operations.

5. Plans Preparation

Because the current individual contraflow plans differed significantly in many aspects, a set of templates has been developed by the FDOT TEOO to assist the Districts in developing uniform and consistent contraflow plans at a statewide level.

In addition to the general requirements for developing uniform plans, several practices employed by many states have potential application in Florida contraflow plans:

- Prepare plans with graphics in a manner that can be easily understood by individuals who have little experience reading plans. Unlike most roadway construction plans that are read by contractors, contraflow plans may be distributed to a broad array of individuals, such as managers, filed supervisors, and operational staff of different agencies, including state emergency operations and law enforcement personnel. Examples of this technique include enlarging the areas with exit and entrance ramps to show device placement details.

- Prepare the plans in a manner or format that can be easily broken up and distributed to separate individuals. Examples of this practice include showing one entire interchange in one sheet and including graphics that can be reproduced on an 8½-inch by 11-inch sheet of paper.

- Prepare text-based operational plans to compliment the graphic plans. The operational plans typically include timelines that work backward from the storm's expected arrival and that give key deadlines for specific tasks to be completed. They also have contact information for all supervisory and managerial staff expected to be involved; the hotels that can be used to house temporarily relocated personnel; and how to contact medical facilities.

- Prepare a plan for the patrol personnel that assist motorists on the contraflow route. The plan should show the route(s) that should be used to return to the starting point of their patrol sector, assuming the possibility that the patrol personnel are perhaps unfamiliar with either the area or their assigned routes.

6. Miscellaneous Practices

There are many practices other states have applied that are recommended for statewide contraflow plan use in Florida. These best practices are generally low cost and, while they do not have dramatic impacts on evacuation success, they can ease setup and plan operation, and improve the public's perception of the evacuation:

- Paint thermoplastic interchange exit numbers on the pavement so that when aerial surveillance is used to patrol contraflow operations, the pilots can identify the interchange they see.
- Permanently mark temporary contraflow signage locations on the pavement of contraflow lanes so that signs can be placed quickly during contraflow deployment.
- Replace the terminal end of guardrails with SRT-350 anchor ends to reduce the hazard of having a sharp guardrail end facing the contraflow traffic.
- To help monitor contraflow operations, use combination ITS trailers that contain VMS devices, closed-circuit televisions (CCTVs), HAR equipment, vehicle detection systems, and telephone communications on freeways that do not have ITS components.
- Use satellite-based networks to support portable VMS devices to avoid dependency on cellular telephone technology.
- Use the existing Road Ranger Service Patrols, redeployed to the contraflow area, to support the evacuation, assist motorists, and keep traffic flowing.
- Place emergency supplies such as water, maps, and first-aid kits at rest areas along the contraflow route.
- Place FDOT personnel at rest areas along the contraflow route to assist motorists, provide customer service, and minimize questions from other FDOT personnel actively involved in traffic management.
- Use flip-down signs on the contraflow side to advise motorists of upcoming exits and of distance-to-destination information. An average of three flip-down signs per interchange is likely.

7. Contraflow Operations with Future ITS Development

Intelligent transportation system technologies, particularly CCTV cameras, have been well liked when used to assess contraflow operations or the need for these types of reverse-lane evacuation procedures. The following is a summary of the states that utilize CCTV cameras in their hurricane evacuation plans:

- *Georgia* – The GDOT uses six ADDCO SmartZone® trailers on the I-16 contraflow route.[3] The trailers have a portable VMS, a CCTV camera, HAR, and vehicle detection devices for data collection. These devices were installed on specially designed hard-surface pads that had power and telephone connections located immediately adjacent to them, which enable them to relay data back to Atlanta for traffic control and monitoring.

- *South Carolina* – The South Carolina Department of Transportation (SCDOT) used CCTV cameras to assess contraflow operations on the Charleston section of the I-26 route and in the Bluffton area of U.S. Highway 278 for the Hilton Head Island contraflow route.

- *Texas* – The TxDOT used Houston TranStar CCTV cameras to monitor the contraflow routes for Interstates 10 and 45. The CCTV images were available at a TranStar Web site that provided information to motorists and officials throughout the state. A media room in Austin was operated throughout the hurricane evacuation period to disseminate information. This media room concept was also used by Alabama during its recent evacuations as a means to distribute general evacuation information.

- *Virginia* – The VDOT used CCTV cameras, DMS units, and vehicle detection devices on the I-64 contraflow route to monitor the traffic immediately north of and south of the Hampton Roads Bridge Tunnel.

The FDOT is progressing with ITS developments throughout urban and suburban areas in Florida. The following is a summary of the status of ITS developments for various contraflow routes:

- Florida's Turnpike has 3 HAR transmitters and 11 CCTV cameras along its contraflow route. An upcoming project will provide additional cameras spaced one per mile, with the installation expected to be complete by the end of 2006.

- Interstate 4 has one CCTV camera located at the I-4/I-275 interchange. This camera will be replaced with four cameras by the end of 2006.

[3] Smart Zone is a registered trademark of ADDCO, Inc.

- Interstate 10 has CCTV cameras at the I-295 end in Jacksonville, but there are no ITS devices at the I-75 end.

- For the I-75 Alligator Alley area, the FDOT Districts have an ITS planning and device location effort underway that will result in the installation of ITS devices throughout the corridor.

- State Road 528 has full coverage using automatic vehicle identification (AVI) data collection sensors along the contraflow route to generate travel times and speeds. Closed-circuit televisions cameras will be installed every two miles by mid-2006, and six DMS devices will be installed by the end of 2007. One of the DMS devices will be installed east of SR 520 and could be used in conjunction with contraflow operations.

- Florida is also designing and installing CCTV cameras at numerous locations statewide to provide additional video monitoring in association with contraflow activities. Proposed locations include:
    - I-95 and the Florida state line
    - I-95 and Florida's Turnpike at Fort Pierce
    - I-75 and I-275 South
    - I-75 and I-4
    - I-75 and I-275 North
    - I-75 and Florida's Turnpike
    - I-75 and U.S. Highway 27
    - I-10 and I-75
    - I-10 and U.S. Highway 19
    - I-10 and U.S. Highway 231
    - I-10 and SR 85
    - I-10 and U.S. Highway 29
    - I-10 and Florida state line
    - I-10 and U.S. Highway 319
    - I-75 and the Florida state line
    - I-10 and U.S. Highway 301