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Determining the Suitability of Freeway Corridors for Managed Lanes Deployment

Virginia P. Sisiopiku*, Sara Alnazer**
*(Department of Civil, Construction, and Environmental Engineering, University of Alabama at Birmingham, USA)
** (Department of Civil, Construction, and Environmental Engineering, University of Alabama at Birmingham, USA)

ABSTRACT
Previous research and deployment efforts showcase the potential benefits of managed lane strategies toward increasing the utilization and efficiency of transportation facilities, and reducing congestion and related impacts. However, criteria for determining the suitability of a specific highway corridor for deployment of managed lane strategies are less well established. This paper reports on a study that incorporated best practices to develop a standardized screening and evaluation methodology leading to the identification of promising corridors for managed lanes deployment. Best-suited managed lane strategies for the selected corridors are also identified. The methodology is then used to screen potential corridors in Alabama's largest urban areas based on the proposed assessment criteria and desired outcomes. The findings are expected to provide valuable guidance to transportation professionals and decision makers towards selecting appropriate corridors for implementation of managed lanes based on need, feasibility, and potential return for the investment.

Keywords – **High Occupancy Vehicle Lanes (HOV), Managed lanes, Ranking Methodology**

1. INTRODUCTION
The continued increase in the traffic congestion, especially in the major metropolitan areas, costs the US economy billions of dollars every year through lost productivity, wasted fuel and increased air pollution. The growth in vehicle miles traveled (VMT) continues to outpace lane mile growth across the country. Expansion of the transportation infrastructure in order to accommodate the growing traffic demand faces several obstacles such as highway construction costs, limited right-of-way, environmental and societal concerns [1]. Thus the need for alternative ways to improve the traffic flow and reduce congestion becomes urgent. Among available options, managed lanes (ML) have demonstrated effectiveness toward providing congestion relief through the increase of existing highway utilization rather than expansion of the roadway infrastructure. Managed lanes are highway facilities or dedicated lanes where operational strategies are proactively implemented and managed in response to changing conditions.

In Alabama, recurrent congestion on main highways continues to increase due to the rise in the population and vehicle miles traveled [2]. Census data confirm that the population in Alabama has increased by 18% from 1990 to 2008 and is expected to reach 5.6 million people by 2030, or 16% more than the 2010 count [2]. Furthermore, a study conducted by the Reason Foundation concluded that the congestion level in Alabama's urban areas is likely to increase significantly by 2030 unless actions are taken to accommodate the surging demand [3]. Implementation of managed lane options can be an effective way to control congestion increase in Alabama highways corridors and reduce its undesirable impacts.

In the recent years, the Regional Planning Commission of Greater Birmingham (RPCGB) has demonstrated a strong interest in managed lanes for the Birmingham, Alabama region. However, other areas across the State of Alabama may also benefit from managed lanes in the near and long term future. Therefore, consistent screening methods and evaluation criteria should be used to evaluate the need for managed lane implementation, leading to a statewide comprehensive managed lane program plan. This will allow State transportation officials to allocate funding in the most efficient manner and effectively prioritize projects.

2. STUDY OBJECTIVES
The main objective of this investigation was to develop a screening methodology leading to the identification of promising corridors for managed lanes implementation. A case study was used to

demonstrate the feasibility and value of the methodology toward identification of candidate corridors for managed lanes in the four largest urban areas in the State of Alabama, namely Birmingham, Montgomery, Huntsville, and Mobile.

3. APPROACH AND METHODOLOGY

The study objective was accomplished through: (1) Performing a literature review to determine appropriate assessment criteria and related data for corridor analysis; (2) Proposing and testing a screening methodology to identify highway corridors that are suitable for managed lane treatments in the State of Alabama; (3) Developing and demonstrating a standard assessment methodology to determine the most appropriate managed lane strategy that can be used based on the local priorities and needs; and (4) Evaluating physical criteria for the potential managed lane deployment to ensure feasibility of implementation.

3.1 Candidate Screening Assessment Criteria

Review and synthesis of best practices from various studies led to the development of a set of six assessment criteria to be used for screening candidate corridors in order to determine their need for managed lanes implementation. These considered vehicle volumes, truck volumes, facility level of service, congested travel speed, congested travel time and traffic safety. Scores ranging from 1 to 3 were proposed to rate corridors or corridor segments based on the need for managed lanes deployment as discussed next.

3.1.1 Threshold I: Vehicular Volumes

The first screening criterion considered was the average Annual Daily Traffic (AADT) and was used to identify corridors (or corridor segments) that carry heavy traffic volumes. Table 1 presents the rubric used to score facilities according to AADT [4].

Table 1: Average Annual Daily Traffic (AADT) per lane and Prioritization score

Score	1	2	3
Criterion	Greater than 20,000	15,000 to 20,000	Less than 15,000

In Table 1, corridors with AADT above the passing threshold (e.g., score 1) were given an advance for high priority consideration depending on their performance in subsequent thresholds. Corridors with score 2 or closer may be considered for medium to long-term managed lane implementation whereas corridors with score 3 were recommended for elimination from managed lane consideration. However, the other criteria should be investigated as well and a corridor selection decision should be made after all criteria are reviewed and evaluated.

3.1.2 Threshold II: Truck Volumes

The volume of trucks using the facility was another criterion that was considered when evaluating a corridor for potential managed lanes implementation. Earlier studies have proposed a variety of criteria to identify candidates for truck-only lanes. The thresholds shown in Table 2 were adopted in this study form a comprehensive study conducted by Chu and Meyer [6].

Table 2: Threshold II- Truck Volumes

Score	1	2	3
Criterion	Truck volumes in each direction $\geq$ 8,000 trucks/day	Truck volumes in each direction 6,500 to 8,000 trucks/day	Truck volumes in each direction $\leq$ 6,500 trucks/day

For the prioritization segment score used in this study, the following rating scale was developed:

- Score 1: for segments that meet threshold of 8,000 or more trucks/day/direction;
- Score 2: for segments that meet between 80% and 99 % of the 8,000 trucks/day/direction threshold; and,
- Score 3: for segments 80% or more below the threshold.

3.1.3 Threshold III: Peak Hour Level of Service

The third screening criterion considered was the measure of the level of congestion for the corridor (or segment). The level of congestion was measured mainly by calculating the Level of Service (LOS) according to the procedures of the Highway Capacity Manual [6].

Chronic congestion is defined in the literature as 2-hrs at LOS E or worse per peak period for highway and other access-controlled facilities and are

good candidates from managed lanes deployment. Facilities currently operating at LOS C or D during peak conditions that are likely to have growth in traffic congestion may be selected for medium and/or long term consideration for managed lanes applications. Further, facilities currently operating at LOS A or B; or operating at LOS C or D but are not likely to have traffic growth, should be deferred from high-priority consideration.

Based on the experience with managed lane projects as reported in the literature, when peak hour LOS in the general use lane is F, a managed lane will experience a LOS of D, which is a major improvement in traffic operations. Table 3 shows the rating score that was used in this study to evaluate the suitability of study corridors for managed lane implementation according to LOS thresholds [4].

Table 3: Threshold III- Peak Hour LOS

Score	1	2	3
Criterion	LOS F	LOS E	LOS D or better

3.1.4 Threshold IV: Congested Travel Speed

This criterion considered the travel speed during the peak hour. The average peak hour speed was calculated based on the average of two consecutive peak hours [5]. Corridors with average speed below this value will have a priority for managed lanes whereas those with speeds higher than the average peak hour speed will be assigned for medium or long-term consideration.

According to the WSDOT's congestion measurement thresholds [7], a speed of 35 mph or less represents severe traffic congestion, where as speeds in the range of 35 to 45 mph indicate congestion presence. Speeds greater than 45 mph are considered to provide reasonable throughput and do not require action [7]. Based on these considerations, the scores proposed and used in this study for rating managed lanes candidates based on peak hour travel speed are summarized in Table 4 [4].

Table 4: Threshold IV- Congested Travel Speed

Score	1	2	3
Criterion	35 mph or less	35-45mph	Greater than 45 mph

3.1.5 Threshold V: Travel Time Savings

Potential travel time savings were also used as a criterion for screening corridors for managed lanes implementation and threshold values are summarized in Table 5.

Table 5: Threshold V- Travel Time Savings

Score	1	2	3
Criterion	Greater than 1 min/mile	½ to 1 min/mile	Less than a ½ min/mile

3.1.6 Threshold VI: Traffic Safety

Managed lanes deployment may be also driven by safety considerations. The incident and accident safety thresholds adopted in this study are presented in Table 6 below [5]. A significant incident is defined as any incident that exceeds 20 minutes in duration. A corridor undergoing screening advances for further consideration if there are more than 50 significant incidents per year. The crash rate ratio is calculated as the corridor (or segment) average annual accident rate per million vehicle miles (MVM) divided by the statewide rate by facility type. If either the incident threshold or the crash threshold is met, the corridor is considered to satisfy Threshold VI and is a good candidate for managed lanes implementation [5].

Table 6: Threshold VI- Traffic Safety

Expressways, and Parkways			
Incidents >20 Min Duration	**Statewide Crash Rates by Facility Type and Location**	**Crash Rate Ratio**	**Score**
≥50/year – Advance	6-lane Expressway=1.19	≥ 1	1
<50/year – Defer	4-lane Parkway=1.12 6-lane Parkway=1.35	0.9 to 1	2
	8-lane Parkway=1.15	≤ 0.9	3

3.2 Implementation of Screening Criteria to Alabama Study Corridors

In this study, seven corridors were investigated and analyzed for managed lanes consideration. The corridors are located in the four largest cities in Alabama, namely Montgomery, Mobile, Huntsville, and Birmingham and represent the main Interstate highways in Alabama (namely I-65, I-85, I-10, I-20/59, and I-565).

First, all candidate corridors underwent a screening process that considered criteria related to traffic volume (average total daily traffic), truck volume, presence of congestion, congested travel speed, potential travel time savings, incidents and accidents data as described in Section 3.1. The process provided a systematic way to determine its corridor's suitability and need for managed lanes implementation. Excel spreadsheets were developed in order to carry out all the calculations.

Required traffic data, such as average annual daily traffic (AADT) for 2010, and percent truck volume were obtained from the Alabama Department of Transportation (ALDOT). For the Birmingham corridors, the congested travel speeds were collected from the Birmingham Metropolitan Planning Organization whereas for corridors located in Montgomery, Mobile, and Huntsville the congested travel speeds were estimated using the 2011 Urban Mobility Report [8]. Additional data, such as travel time savings and travel time index, were calculated from the 2011 Urban Mobility Report [8]. The LOS analysis was conducted according to the Highway Capacity Manual 2000 procedures [9]. The crash data for Alabama were obtained from the Critical Analysis Reporting Environment (CARE) for Alabama [10].

4. RESULTS

The proposed methodology was applied to determine if the study corridors were good candidates for implementation of managed lanes at present. Additional calculations were also performed to rank study sections for future traffic demand conditions (i.e., projected for 2030).

Corridors were ranked based on their overall scores and the ones with scores less than 2 are recommended as high priority for near term managed lanes consideration. For those corridors additional analysis was performed in order to identify the best-suited managed lane strategy among a range of possible options such as High Occupancy Vehicle lanes (HOV), High Occupancy Toll lanes (HOT), exclusive truck lanes etc. Segments with average rating scores between 2 and 3 were rated as good candidates for managed lanes in the future while those with scores 3 and above were not found appropriate for managed lanes applications.

For the sake of brevity, one study corridor (Corridor 7) was selected and used to demonstrate the application of the abovementioned methodology in this paper. Detailed analysis of the remaining six corridors considered is available in [11] and summary findings are discussed below.

4.1 Demonstration Corridor Results

Corridor 7 is located on I-20/59 in the city of Birmingham and extends from the junction of I-20/59 and I-65 to the junction of I-20/59 and I-459. This corridor is used to demonstrate the application of the screening methodology described earlier. The study corridor is 12.48 long and is a major commuter route that carries 153,460 vehicles per day. The speed limit is 60 mph. The corridor was divided into 9 segments that are used in the analysis below.

4.1.1 Evaluation of Corridor 7 for Threshold I- Vehicular Volumes

The screening results for Corridor 1 with respect to Threshold 1 are shown in Table 7. It can be seen that Segment 1 of this corridor is good candidate for managed lanes implementation (score 1) on the basis of AADT. Segments 2, 3, 4, and 7 may be considered for medium to long-term managed lane implementation.

Table 7: Screening for Vehicle Volume Criteria- Corridor 7

Seg-ment#	#Lanes/ direction	AADT	AADT per lane	Score
1	**4**	**158,940**	**19,867**	**1**
2	4	153,560	19,195	2
3	4	142,340	17,792	2
4	4	135,450	16,931	2
5	3	79,030	13,171	3
6	3	67,010	11,168	3
7	2	68,380	17,095	2
8	2	55,390	13,847	3
9	2	39,950	10,492	3

4.1.2 Evaluation of Corridor 7 for Threshold II- Truck Volumes

Table 8 shows the daily truck volumes for Corridor 7 as well as the corresponding score ratings of its segments based on Threshold Criteria II (Table 2).

Table 8: Evaluation for Truck Volume Criteria- Corridor 7

Segment #	% Daily Truck	Daily truck volumes per direction	Score
1	**10**	**7,947**	**1**
2	10	7,678	2
3	11	7,829	2
4	11	7,450	2
5	8	3,161	3
6	9	3,015	3
7	10	3,419	3
8	11	3,046	3
9	15	2,996	3

The results identify Segment 1 as a prime candidate for managed lanes on the basis of truck volume. Segments 2, 3, and 4 have heavy truck volumes and may benefit from managed lanes in the medium to long-term future.

4.1.3 Evaluation of Corridor 7 for Threshold III- LOS

The LOS during peak was calculated for each sub section of Corridor 7 and scores were assigned according to screening assessment criteria for Threshold III as listed in Table 9. The LOS analysis confirms that Corridor 7 offers a poor quality of service during peak periods. Specifically, segments with of LOS of F (i.e., Segments 3, 5, 7, and 8) require immediate action for alleviation of traffic congestion and are excellent candidates for managed lanes deployment. Overall, the corridor appears to be a good candidate for managed lanes implementation on the basis of congestion considerations.

Table 9: Screening for LOS criteria- Corridor 7

Segment #	V/C	LOS	Score
1	0.98	E	2
2	0.89	E	2
3	**1.13**	**F**	**1**
4	1.14	E	2
5	**1.14**	**F**	**1**
6	0.97	E	2
7	**1.49**	**F**	**1**
8	**1.21**	**F**	**1**
9	0.89	E	2

4.1.4 Evaluation of Corridor 7 for Threshold IV- Congested Travel Speed

The congested travel speed for each segment of Corridor 7 are displayed in Table 10 along with the corresponding scores. Segments with score 1 (i.e., Segments 1, 4, and 8) have priority for managed lanes implementation in the near future.

Table 10: Evaluation for Congested Speed Criteria- Corridor 7

Segment #	Congested Speed (mph)	Score
1	**35**	**1**
2	45	2
3	45	3
4	**28**	**1**
5	40	2
6	45	2
7	38	2
8	**35**	**1**
9	45	2

4.1.5 Evaluation of Corridor 7 for Threshold V-Travel Time Savings

The travel time savings (min/mile) were calculated for each segment of Corridor 7 and used to obtain a score. Table 11 lists the data used in order to evaluate the corridor sub segments according to Threshold 5. According to the methodology in the 2010 Urban Mobility Report [8], if the value of the TTI exceeds 1.22, the section experiences one or more hours of congestion. On the basis of travel time savings and according to the results displayed on Table 11, Segment 4 is a prime candidate for managed lanes implementation and most of the remaining corridor segments are likely candidates for future managed lanes deployment (Score 2).

Table 11: Evaluation for Travel Time Saving Criteria- Corridor 7

Segment #	Segment Delay (sec)	TTI (Travel Time Index)	TT Savings (min/ mile)	Score
1	66	1.71	0.71	2
2	60	1.50	0.50	2
3	43	1.54	0.54	2
4	**49**	**2.14**	**1.14**	**1**
5	45	1.50	0.50	2
6	8	1.33	0.33	3
7	53	1.58	0.58	2
8	28	1.71	0.71	2
9	56	1.33	0.33	3

4.1.6 Evaluation of Corridor 1 for Threshold VI- Safety

The crash data (i.e., fatal, injury, and property damage only-PDO) were considered for each segment of Corridor 7 and scores were obtained in accordance to proposed safety-related criteria shown in Table 12. The results indicate that Segments 1, 2, 3, 7, and 8 experience traffic safety issues and could benefit from managed lanes on the basis of safety.

Table 12: Evaluation for Safety Criteria- Corridor 7

Segment #	Fatal	Injury	PDO	Crash Rate Ratio	Score
1	**3**	**128**	**712**	**1.70**	**1**
2	**6**	**155**	**804**	**1.60**	**1**
3	**2**	**67**	**327**	**1.03**	**1**
4	1	17	57	0.50	3
5	0	0	8	0.15	3
6	0	32	71	0.64	3
7	**6**	**37**	**118**	**1.19**	**1**
8	**2**	**20**	**106**	**1.16**	**1**
9	**2**	**41**	**197**	**1**	**1**

4.1.7 Corridor 7 Composite Rating

Table 13 summarizes all scores for Corridor 7 and displays the average rating per segment and the overall corridor average score. As it can be observed that several study segments have scores that are ones and twos, resulting in an overall score for Corridor 7 of 1.90. This is below the threshold value of 2 indicating that this corridor is an excellent candidate for consideration for managed lanes implementation.

4.2 Identification of Candidate Corridors for Managed Lane Consideration

In a similar manner, scores for all criteria and for every segments of all remaining corridors were determined and overall scores were calculated and used to rank the corridors with respect to the need for managed lanes implementation as shown in Table 14.

Based on the comparison of results from all seven investigated corridors in the Alabama case study, it is clear that the Birmingham Corridor (Corridor 7) is the only one that has high priority for managed lanes consideration at the present time as all other scores are below the 2.00 threshold value. Therefore, Corridor 7 is selected for further analysis that would consider the type of managed lanes option that is most appropriate for addressing the corridors needs and priorities.

Table 13: Segment Prioritization Results for Corridor 7

Segment #	Criteria I	II	III	IV	V	VI	AVG Rating
1	1	1	2	1	2	1	**1.33**
2	2	2	2	2	2	1	**1.83**
3	2	2	1	2	2	1	**1.67**
4	2	2	1	1	1	3	**1.67**
5	3	3	1	2	2	3	**2.33**
6	3	3	2	2	2	3	**2.50**
7	2	3	1	2	2	1	**1.83**
8	3	3	1	1	2	1	**1.83**
9	3	3	2	2	2	1	**2.17**
Corridor 7 overall weighted score: 1.90							

4.3 Determination of Best Managed Lanes Strategy

Next, a screening for the best managed lane strategy was performed for the Birmingham Corridor (Corridor 7, I20/59). The screening was conducted using the Strategy Selection Screening Tool.

The program was developed in Visual Basic.NET and was provided by the Managed Lanes Handbook in a compact disk [12]. This program requires certain inputs to the model such as objectives, constraints and weights selected for the study corridor to reflect local considerations. A detailed explanation of the inputs of this program is available in [11].

Based on scores assigned (Table 15), the best managed lane strategy along the I20/59 study corridor (Corridor 7) is an HOV lane, followed by HOT lane and toll express lane options. Thus, an HOV strategy is recommended as the best possible managed lanes option for addressing the needs of Corridor 7.

Table 14: Ranking of Study Corridors with Respect to Needs for Managed Lane Implementation

Rank	Corridor	Score	Managed Lanes Priority	Time Frame
1	7: I-59/20-Birmingham	**1.90**	**High**	Near term
2	4: I-10-Mobile	**2.37**	**Medium**	Medium term
3	1: I-65-Montgomery	**2.47**	**Medium**	Medium / Long term
4	5: I-10-Mobile	**2.51**	**Low**	Long term
5	2: US-80-Montgomery	**2.67**	**Low**	Long term
6	3: I-10-Mobile	**2.89**	**Low**	Long term
7	6: I-565-Huntsville	**2.89**	**Low**	Long term

4.4 Evaluation of Suitability of HOV Strategy for Corridor 7

This evaluation step is essential to ensure that the HOV lane will be efficient in addressing needs of the study corridor. The evaluation criteria are listed in Table 9, and have been used previously in other studies [12]. They consider traffic congestion; travel time expected savings; physical limitations; right-of-way (ROW) requirements, and minimum demand thresholds. If a positive determination cannot be made for any of the factors listed, then HOV treatment should be deferred from high-priority consideration.

Based on the analysis conducted in this study, an HOV lane is a suitable managed lane strategy for the Corridor 7 as it meets need, feasibility, and demand related objectives.

Table 155: Evaluation of HOV Strategy for Corridor 7

Criteria	Thresholds for HOV Lanes	Compliance
Congestion	Predictable locations of congestion at LOS E or F for 2 or more consecutive peak hrs in the peak direction during AM and PM peaks Congestion along a significant portion of the corridor (over 60%)	**Yes**
Travel time savings	Minimum of 1 minute per mile travel time savings over prevailing general-purpose lane conditions	**Yes**
Right-of-way characteristics for HOV deployment	Minimum available median width of 26 feet Minimum lane width per direction of 12 feet (concurrent or contra-flow) outside of right shoulder (rather than take away lane) 20 feet (reversible flow). ROW for periodic enforcement areas	**Yes**
HOV/Managed Lane Demand	Min demand threshold for the implementation year (400-800 vph/ directionally), otherwise consider pricing others to reach minimum vehicle volume.	**Yes**

5. CONCLUSION

This paper described and demonstrated a screening and evaluation methodology leading to the identification of promising corridors for managed lanes deployment. Moreover, it determined best-suited managed lane strategies for the selected corridors. The procedures introduced in this paper are expected to provide valuable guidance to transportation professionals and decision makers towards selecting appropriate corridors for implementation of managed lanes based on need, feasibility, and potential return for the investment.

As part of a case study presented in the paper, seven interstate highway corridors in Alabama have been investigated for the potential of applying managed lanes to address current and future congestion problems. The corridors are located in the four largest cities in Alabama, i.e. Birmingham, Montgomery, Huntsville, and Mobile and along interstate highways I-65, I20/59, I-85, I-10, and I-565. The following conclusions can be drawn from this study:

- A 9.4-mi long stretch of I-20/59 corridor in Birmingham extending from Tallapoosa St. (Exit 128) to I-459 (Exit 137) is proven to be a good candidate for immediate consideration for managed lanes implementation. Thus it is recommended as short term priority corridor for managed lanes deployment.
- Based on the results from a detailed strategy screening, HOV is the best suitable managed lane strategy for the Birmingham corridor. Furthermore, the HOV lane demonstrated to be an efficient solution. Alternative strategies for managed lanes along I20/59 include HOT lanes and Toll Express lanes.
- None of the remaining six study corridors shows an immediate need for managed lane consideration. However, based on the results from the analysis, Corridor 4 in Mobile located on I-10 from Theodore-Dawes Rd to I-65 S, and Corridor 1 on I-85 from I-65 to Taylor Rd in Montgomery can be considered for medium-term future managed lanes deployment.

6. RECOMMENDATIONS

In future studies, it is recommended that estimates of implementation costs and annual operating and maintenance costs be considered in order to determine the Life-Cycle Costs prior to making the final decision for adoption. Also detailed design plans are needed to guide the construction process. Moreover, media campaigns are recommended to introduce the HOV lane concept to motorists and gain their support for the new treatment. Last but not least, "before" and "after" studies are recommended to evaluate impacts of managed lanes implementation

on traffic operations and safety at and around the implementation site.

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