



To:	Danielle Spila, Bureau of Public Transportation Director, PA Department of Transportation AJ Jordan, Manager of Planning and Scheduling, Lehigh and Northampton Transportation Authority	From:	Gregory Lebo, Stantec, Senior Associate Mechanicsburg, PA
	Allentown, PA		
Project/File:	2027131626	Date:	August 30, 2023

#### Introduction

The PennDOT Bureau of Public Transportation (BPT) engaged Stantec Consulting Services Inc. (Stantec) to develop and perform fatal-flaw evaluations on concepts for providing a Bus Rapid Transit (BRT) service for the Lehigh and Northampton Transportation Authority (LANTA) along MacArthur Road from Royal Avenue to Jordan Parkway in Whitehall Township, PA, located north of the City of Allentown, PA. The deliverable of this project is a "roadmap" consisting of a series of incremental phases leading to a more fully enhanced bus system along MacArthur Road (PA State Route 145). This memo describes the process followed that culminated in the "roadmap" of phased improvements.

#### **Background Information**

This "roadmap" builds upon the LANTA Transit First Corridor Plan. This Plan included three projects in the MacArthur Road corridor, these being:

- 1. MacArthur Road (Royal Avenue to Sumner Street)
- 2. MacArthur Road & Mickley Street
- 3. MacArthur Road & Jordan Parkway

In an effort to address the needs identified to be addressed by the three aforementioned projects that were to be pursued by LANTA, the length of corridor to be investigated by this BRT Study included MacArthur Road from the north at Royal Avenue to the south at Jordan Parkway. Numerous BRT service concepts were considered for this study, but the following three concepts were ultimately chosen as discussed further on in this memo:

- Phase 1: Transit Access/Facilities
- Phase 2: Business Access and Transit (BAT) Lanes
- Phase 3: Pre-signal/Median lanes

A series of meetings were held with PennDOT (BPT and District 5), LANTA, Whitehall Township, and the Lehigh Valley Planning Commission to discuss the purpose and need of this project, as well as the pros and cons of each of the aforementioned phase concepts for BRT service on MacArthur Road (see Appendix A).

#### EXISTING CORRIDOR CHARACTERISTICS

The portion of MacArthur Road (PA State Route 145) within the BRT study area is classified by PennDOT as a Principal Arterial Highway and is a heavily-traveled commuter route extending north of the City of

Allentown that generally has southbound and northbound traffic peaking characteristics during the AM and PM peak hours, respectively. The corridor has three segments with distinctive cross-section and traffic flow characteristics:

- South of Jordan Creek This is the most lightly-traveled segment of the corridor with two travel lanes provided in each direction and left-turn movements from MacArthur Road completed from the median of the roadway;
- Jordan Creek to Route 22 This segment generally consists of two travel lanes in each direction with left-turn movements completed via turning bays in the median, and a partial cloverleaf interchange with two signalized intersections facilitating all movements to and from Route 22;
- North of Route 22 This is the most heavily-traveled segment of MacArthur Road and consists
  of three travel lanes in each direction with left-turn movements from Route 145 being completed
  via both near side and far side jughandles on the corridor.

Table 1 covers data collected at the major intersections within the study area, noting general cross section dimensions, AADT, and crash statistics.

Proposed Improved Location	Roadway Name(s)	Roadway (Seg/Off)	Roadway Length	Roadway Cross Section Description & Measurements	AADT	Crash Comparison (2015 to 2019)
	MacArthur Road	SR 0145 (0130/0000)		80' cartway Width 12' lanes Divided by a concrete median	20,268	
MacArthur Rd/Mickley Rd	Mickley Road	Non-State Roadway	Intersection	Two-lane road 46' cartway width 12' lanes Both approaches have separate left and right turn lanes.	No Data Available	15 crashes
MacArthur Rd/Schadt Ave	MacArthur Road	SR 0145 (0140/0000)	Intersection	Six-lane Road 81' cartway width 12' lanes Divided by a concrete median	20,268	30 crashes

#### Table 1. Existing Roadway Characteristics

Proposed Improved Location	Roadway Name(s)	Roadway (Seg/Off)	Roadway Length	Roadway Cross Section Description & Measurements	AADT	Crash Comparison (2015 to 2019)
	Schadt Avenue	SR 1008 (0020/2539)		Two-lane road 46' cartway width 12' lanes Both approaches have separate left and right turn lanes.	9,587	
MacArthur Rd/Fairmount Ave	MacArthur Road	SR 0145 (0110/0000)	)) Intersection	Four-lane Road 64' cartway width 12' lanes Divided by a concrete median	25,599	50 crashes
	Fairmont Avenue	Non-State Roadway		Two-lane road 40' cartway width	3,465	
MacArthur Rd/Jordan Parkway	MacArthur Road	SR 0145 (0100/2047)	Intersection	Four-lane Road 66' cartway width 12' lanes Divided by a concrete median	25,599	25 crashes
	Jordan Parkway	Non-State Roadway		Two-lane road 36' cartway width	No Data Available	

#### TRANSIT SERVICES AND NEEDS

MacArthur Avenue is a link for the following bus routes, which serve part or all of the study area:

- Green Line: South Bethlehem to Allentown to Whitehall Central Mall weekday and Saturday service with half hour headways from roughly 8 am to 11 pm
- Route 103: South Bethlehem to Allentown to Northampton weekday and Saturday service with hour headways from roughly 5 am to midnight
- Route 211: Lehigh Parkway to ATC (Allentown Transit Center) to Whitehall weekday and Saturday service with hour headways from roughly 5 am to 8 pm
- Route 319: Lehigh Valley Mall to Bethlehem Square via Lehigh Valley Airport only early morning and late night bus service uses MacArthur Road to access ATC with express service
- Route 603: Parkway Shopping Center to Lehigh Valley Mall weekday service with hour and a half headways from roughly 7 am to 7 pm

Currently, many of these bus services suffer from circuitous routing, which increases running times on these routes, especially those accessing the malls along MacArthur Road, making transit options to those in Whitehall Township less attractive. The improvements being proposed within this project seek to propose accessibility and mobility improvements to actualize the potential for access to ridership for boarding and alighting on MacArthur Road. Paired with the phased implementation of bus right-of-way improvements on MacArthur Road (bus stop facilities to BAT lanes to median lanes), these improvements will help to improve bus travel times, which in turn will increase ridership for retail- and residential-based trips.

#### **RELEVANT STUDY AREA PROJECTS**

The following projects has been identified as being relevant to the BRT study area due to the need to coordinate transit priority improvements:

- ECMS #85144: Diverging Diamond Interchange at US Route 22 Interchange with Route 145;
  - Work by PennDOT District 5-0 as part of improvements on Route 22 corridor
    - o Currently in preliminary design with AECOM
    - Work limits extend from Jordan Parkway to the south to Grape Street to the north
    - o Includes widening of Route 145 over Jordan Creek to provide six travel lanes
- ECMS #110170: MacArthur Road Signal Optimization
  - Work by PennDOT District 5-0 to provide improvements to accessibility and congestion
  - Final design of improvements completed by McCormick Taylor last year
  - Work limits extend from Grape Street past northern end of study area
  - o Includes signal timing and offset optimization improvements for all signals on this stretch
  - Includes ADA work at Mickley, Whitehall Square, Schadt, and Sutler intersections

#### Transit Priority Options Considered

The most significant element in determining the speed and reliability of BRT services on Macarthur Road is the running way (the lane in which the vehicle travels). The more the BRT's running way is separated from general traffic, the better the service can control its speed and reliability. The running way design also significantly impacts the image and identity of the system.

Depending on the technique selected, the BRT service will fall along a spectrum of running way configurations. At one end of the spectrum is BRT "lite," which uses combinations of system elements, such as queue jump lanes (short, dedicated lanes at intersections that allow the BRT vehicles to "jump" ahead of auto traffic) and transit signal priority (TSP), whose cost is in the lower end of the spectrum. Mostly, the BRT service would operate in shared lanes in mixed traffic. At the other end of the spectrum is "full" BRT, with dedicated running ways exclusive to the BRT service, located either in the

center/median of a road or along the curb/side. Table 2 below describes the variety of BRT options considered in the Macarthur Road corridor.

#### Table 2. BRT Options Considered

Technique	Brief Description of Technique
Mixed Flow Operations with Bus Turn Out	Bus shares curbside lane with general traffic. Areas for the bus to pull-out of the traffic at station locations.
Transit Signal Priority	Additional "green" time is provided at the traffic signal to allow the bus to traverse the intersection,
Queue Jumps	Buses are given an advanced green at a traffic signal. An approach lane to the traffic signal is also provided.
Queue By-pass Lanes	An additional lane is provided to allow the bus to access the traffic signal stop line.
Pre-signaling	An additional traffic signal is installed up-stream of an existing signal to allow the bus to pull in front of general traffic.
BLIMP (Bus Lane with Intermittent Priority)	Traffic signals and overhead lane signs create a space for the bus to travel uninterrupted.
Business Access and Transit Lanes	A curbside bus lane is also used by general traffic to access driveway and undertake right turn maneuvers.
Reversible (Tidal flow) Lanes	A non-peak direction lane is assigned to transit. The bus typically travels in the opposite direction to the traffic.
Contra-flow Bus Lane	A bus lane in the opposite direction to the traffic flow.
Single Two-way Bi-directional Lane	A single bus lane used by buses in both directions.
BRT Curb-side Lanes	Bus lanes located on the right-most (curbside) lane.
BRT Center (Median) Lanes	Bus lanes located in the center (median) of the roadway.

An additional factor is the spacing and configuration of stations along MacArthur Road, as they can improve travel time and reduce dwell time, the amount of time needed to allow passengers to board and alight the BRT vehicle. The suitability of each of these BRT concepts was investigated, which the project team narrowed down to the following preferred concepts:

- Phase 1: Transit Access/Facilities (more indicative of BRT "light")
- Phase 2: Business Access and Transit (BAT) Lanes (more indicative of "full" BRT)
- Phase 3: Pre-signal/ Median lanes (more indicative of "full" BRT)

These three concepts are illustrated at the end of this report in Appendix B.

#### **Evaluation of BRT Elements**

The project evaluation consisted of a high-level assessment of the potential of each of the techniques to:

- Improve transit operations in the corridor;
- Minimize impacts on general traffic operations and capacity;
- Fit within existing right of way;
- Capable of being incrementally introduced; and,

• Introduced in a cost-effective manner.

Consideration was also given regarding prospects for catalyzing economic development and potential funding options for the study's recommendations. Based on these criteria, the most promising techniques were for the three distinct sections of the corridor:

#### South of Jordan Creek:

Mixed flow lanes, Queue-jumps, TSP, and Median bus lanes

#### Jordan Creek to R22:

Mixed flow lanes, Queue-jumps, and TSP

#### North of R22:

Business Access and Transit Lanes, TSP, Single, bi-directional bus lane with Pre-signal, Median bus lanes

**Mixed flow lanes** cater to both buses and regular traffic vehicles. Though transit and non-transit vehicles share these mixed flow lanes, special design features are added to enhance transit. These elements include traffic signal prioritization (TSP) and queue jump lanes (special priority lanes that help reduce transit delays at busy intersections and optimize lane integration for buses) help prioritize buses and provide them with right-of-way privileges in these mixed flow lanes. The mixed flow lanes require little to no roadway redesign, making them a cost-effective option for BRT systems seeking improvement over a regular bus system.

**Business Access and Transit (BAT) lanes** are curb lanes used only by right-turning vehicles and buses. They help buses move more efficiently through traffic and provide better access to businesses. Figure 1 illustrates BAT lanes on MacArthur Road.



Figure 1 - Business Access and Transit Lanes

**Pre-signals** are additional signals placed upstream of signalized intersections to facilitate provision of some level of priority to buses and other modes by allowing them to bypass standing queues of cars. Figure 2 illustrates median lanes with pre-signals on MacArthur Road.



Figure 2 – Median lanes with pre-signals

**Median bus lanes** are bus-only lanes located in the center of the roadway, separating buses from mixed traffic congestion, as shown in Figure 3.



Figure 3 - Median Bus Lanes

**Single, bi-directional bus lanes** function as bus-only lanes but allow bus traffic traveling in both directions to share a single lane. Transit signal prioritization technology plays a vital role in an operable bi-directional lane. It indicates lane availability by signaling to buses when it is safe to continue and stopping them at the BRT stations or holding points when the lane is in use. The bi-directional lane provides the same benefits as a singular dedicated lane without needing an additional bus lane, maximizing lane usage. Figure 4 illustrates single, bi-directional lanes on MacArthur Road.



Figure 4 - Single, Bi-directional Bus Lanes

### **Additional Considerations**

#### **PEDESTRIAN FACILITIES**

For transit services to succeed, well-designed and properly functioning pedestrian facilities are needed. Several locations along MacArthur Road have no pedestrian crossings or sidewalks leading to the road. Thankfully, PennDOT is proposing ADA-compliant curb ramp, sidewalk, and crosswalk improvements at many of the signalized intersections on this corridor to eliminate barriers to transit mobility. The "roadmap" developed as part of this study goes one step further to propose additional pedestrian connectivity to unlock additional ridership.

#### MEDIAN TREATMENT

Currently, MacArthur Road has a concrete median barrier that extends the entire length of the study area. This barrier has several functions. However, its most prominent functions are to provide positive separation between northbound and southbound traffic and to curtail left turn maneuvers, which can be made utilizing the various jug-handles. While the barrier is an appropriate means of restricting the left turns, it does occupy a large portion of the street cross-section. Figure 5 shows a typical section of MacArthur Road with the median barrier.



Figure 5 - MacArthur Road: Median

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#### Reference: PennDOT E05224 – Work Order 6 – LANTA BRT Study

 North College Ave, Indianapolis

A concept to the Jersey-style barrier is using a lower barrier that could be "straddled" by a transit vehicle. Figure 6 shows the use of such a barrier on North College Avenue in Indianapolis, Indiana.

Figure 6 - North College Ave, Indianapolis

#### Roadmap

Implementing full BRT at the onset may not be possible, even if that is the final desired outcome. However, to improve transit service reliability and add capacity along a corridor, it is recommended that LANTA adopt an incremental strategy where the various BRT elements are introduced starting in the short term while planning a more comprehensive BRT service as a longer-term goal.

Using evaluation criteria established as part of the study, a three-phase approach was taken to the implementation of the BRT service in the MacArthur Road corridor.

#### Phase 1: Transit Access/Facilities

South of Jordan Creek: Transit Signal Priority, queue-jumps. Jordan Creek to R22: Transit Signal Priority North of R22: Pedestrian crossings, Passenger boarding pads

#### Phase 2: Business Access and Transit Lanes

South of Jordan Creek: Jordan Creek to R22: Transit Signal Priority North of R22: Business Access and Transit Lanes (BAT)

#### Phase 3: Pre-signal/ Median lanes

South of Jordan Creek: Single, two-way bus lane with pre-signals. Jordan Creek to R22: Transit Signal Priority, queue-jumps. North of R22: Business Access and Transit (BAT) Lanes or Median bus lanes

A more detailed description of the various facilities in each phase is shown in Table 3.

#### Table 3 - Facilities at Each Phase

Option		1a	1b	1c	2	3
Location	Facility	Transit Access/Facilities	Transit Reliability	Transit Priority Facilities	Business Access and Transit Lanes (BAT)	Pre- signal/ Median lanes
MacArthur Road	Link	None: Mixed traffic	-	-	-	
Sutler Drive	Intersection/ Station	Pedestrian crossings, Passenger boarding pads (NE and SW)	TSP	N/B Queue Jump	Improved passenger facilities (shelter etc.)	Median station
MacArthur Road	Link	None: Mixed traffic	-	-	N/B and S/B BAT lanes	Median busway
Schadt Ave	Intersection/ Station	Pedestrian crossings, Passenger boarding pads (NE and SW)	TSP	-	-	Median station
MacArthur Road	Link	None: Mixed traffic	-	-	N/B and S/B BAT lanes	Median busway
American Street	Intersection	None	TSP	-	-	-
MacArthur Road	Link	None: Mixed traffic	-	-	N/B and S/B BAT lanes	Median busway
Mickley Road	Intersection/ Station	Pedestrian crossings, Passenger boarding pads (NE and SW)	TSP	-	Improved passenger facilities (shelter etc.)	Median station
MacArthur Road	Link	None: Mixed traffic	-	-	N/B and S/B BAT lanes	Median busway
Grape Street	Intersection	None	TSP	-	-	-
MacArthur Road	Link	None: Mixed traffic	-	-	N/B and S/B BAT lanes	Median busway
Leigh Valley Mall	Intersection/ Station	Pedestrian crossings, Passenger boarding pads (NE and SW)	TSP	N/B Queue Jump	Improved passenger facilities (shelter etc.)	Median station
MacArthur Road	Link	None: Mixed traffic	-	-	N/B and S/B BAT lanes	-

Option		1a	1b	1c	2	3
Leigh Valley Thruway	Intersection	None	TSP	-	-	-
MacArthur Road	Link	None: Mixed traffic	-	-	-	Median busway
Fairmont Ave	Intersection	None	TSP	-	-	-
MacArthur Road	Link	None: Mixed traffic	-	-	-	Median busway
Jordon Parkway	Intersection/ Station	Passenger boarding pads (NE and SW)	TSP	N/B Queue Jump	Improved passenger facilities (shelter etc.)	Median station
MacArthur Road	Link	None: Mixed traffic	-	-	-	
Mickley Road	Intersection	-	-	-	-	Median busway

#### SKETCH PLANS OF ROADMAP

In Appendix A, the three concepts for phased BRT implementation are illustrated. Mobility improvements from ECMS #110170 are illustrated in all concepts; however, the Diverging Diamond Interchange at Route 22 is still in design and, as such, cannot be sketched into our conceptual plans.

Best regards,

STANTEC CONSULTING SERVICES INC.

Gregory Lebo Senior Associate Emailgregory.lebo@stantec.com

Attachment: Appendix A – Project Correspondence Appendix B – BRT Concepts August 30, 2023 AJ Jordan Page 12 of 13

Reference: PennDOT E05224 – Work Order 6 – LANTA BRT Study

# Appendix A Project Correspondence

Design with community in mind

#### Maher, Matthew

Subject: Location:	PennDOT BPT - LANTA BRT/EBS coordination meeting Microsoft Teams Meeting
Start: End: Show Time As:	Thu 7/13/2023 1:30 PM Thu 7/13/2023 2:30 PM Tentative
Recurrence:	(none)
Meeting Status:	Accepted
Organizer: Required Attendees Optional Attendees	Lebo, Gregory Lebo, Gregory; DROSTRON@pa.gov; Scott Vottero; Carey, Graham; AJ Jordan; jlevitsky@pa.gov; Maher, Matthew; dspila@pa.gov; Irackus@whitehalltownship.com; bhite@lvpc.org :c-chfrey@pa.gov; Brendan Cotter; Graham Carey; Nagle, John; Devine, Miles; Becky A. Bradley; Frank Clark; Sheldon Christman; Carl Lagler

# Microsoft Teams meeting

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E05224 – Work Order 6 – LANTA BRT Study Teams Call July 13, 2023 1:30 PM

- Introductions
- Overview of Project Background/Scope
  - PennDOT BPT Work Order
  - o LANTA Transit First Corridor Plan
- Review Project Approach and Goals
  - o Develop Priority Techniques and Evaluation Criteria
- Review of Concept Techniques
  - o Updated Conceptual Sketch Plans
- > Discussion
- > Next Steps
  - o Draft/Final deliverable

#### **Project Schedule – BRT Study**

Task	Task Initiation / Due Dates	Deliverables
1.1: Concept Development	3/7/2023 7/28/2023	<ul><li>Priority Techniques Evaluation</li><li>Concept Report and Sketch Plan</li></ul>

#### Maher, Matthew

Subject: Location:	PennDOT BPT - LANTA BRT/EBS coordination meeting Microsoft Teams Meeting
Start: End:	Thu 6/15/2023 12:00 PM Thu 6/15/2023 1:30 PM
Recurrence:	(none)
Meeting Status:	Accepted
Organizer:	Lebo, Gregory
Required Attendees	Scott Vottero; Carey, Graham; AJ Jordan; jlevitsky@pa.gov; Maher, Matthew
Optional Attendees	:c-chfrey@pa.gov; Brendan Cotter; Graham Carey; dspila@pa.gov; grahamncarey@gmail.com; Koenigkramer, Vanessa A; Nagle, John; Devine, Miles

### Microsoft Teams meeting

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E05224 – Work Order 6 – LANTA BRT Study Teams Call June 15, 2023 12:00 PM

- > Introductions
- > Overview of Project Background/Scope
  - o PennDOT BPT Work Order
    - LANTA Transit First Corridor Plan
- Review Project Approach and Techniques
  - o Priority Technique Goals
- Review of Concepts
  - o Conceptual Sketch Plans
- > Discussion
- > Next Steps
  - o Additional shareholder meeting
  - o Draft/Final deliverable

#### **Project Schedule – BRT Study**

Task	Task Initiation / Due Dates	Deliverables
1.1: Concept Development	3/7/2023 7/28/2023	<ul><li>Priority Technique Evaluation</li><li>Concept Report and Sketch Plans</li></ul>



# **PowerPoint Presentation**

Design with community in mind

# Approach

Goal:

 Develop a "roadmap" leading to the development of a full feature BRT system in the MacArthur Road corridor

Achieved through:

· Incremental development of the bus system

Divided Corridor:

- South (South of R22)
- Central (Interchange/ Bridge)
- North (North of 22)

1

# Concepts considered

- Transit Signal Priority (TSP)
- Queue Jumps
- Queue By-pass Lanes
- Mixed Flow Operations with Bus Turn Outs
- Pre-signaling
- BLIMP (Bus Lane with Intermittent Priority)
- Business Access and Transit (BAT) Lane
- Reversible (Tidal flow) Lane
- Contra-flow Bus Lane
- Two-way Bi-directional Lane
- Curb-side BRT Lane
- Center/Median BRT Lane

# Evaluation Criteria

- Improved transit operations (reliability, directness etc)
- No additional right of way
- No specialized buses
- Maintain existing traffic operations
- Better utilization of what we have

3

### Results of Evaluation

- Business Access and Transit (BAT) Lane
- Pre-signaling
- Center/Median BRT Lane























# Incremental Implementation

Three phases:

- First Phase (Concept 1): Transit Access/Facilities/TSP
- Second Phase (Concept 2): Business Access and Transit Lanes (BAT)
- Third Phase (Concept 3 or 4): Pre-signal/Median lanes or Pre-signal/BAT lanes

#### Maher, Matthew

Subject:LANTA EBS/BRT chatLocation:Microsoft Teams Meeting

Start:Tue 3/14/2023 2:30 PMEnd:Tue 3/14/2023 3:15 PM

Recurrence: Weekly Recurrence Pattern: every Tuesday from 2:30 PM to 3:15 PM

Meeting Status: Accepted

Organizer:Lebo, GregoryRequired AttendeesLebo, Gregory; Brendan Cotter; AJ Jordan; Carey, GrahamOptional Attendees:Levitsky, John; Maher, Matthew; Devine, Miles

## Microsoft Teams meeting

#### Join on your computer, mobile app or room device Click here to join the meeting

Click here to join the meeting

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E05224 – Work Order 6 – LANTA BRT Study start-up Teams Call March 7, 2023 2:30 PM

- Introductions / Project Roles
- Overview of Project Background
  - LANTA Transit First Corridor Plan
  - o LANTA Lehigh Valley Enhanced Bus/BRT Study
  - o LANTA website info
    - https://lantabus.com/ebs/
    - https://vimeo.com/773355792/fb86cc292e
- Review Project Process and Goals
  - Collect/Review Existing Data
  - o Develop Priority Techniques and Evaluation Criteria
  - Develop Sketches and Future Roadmap
- Review of Overall Schedule and Deliverables
  - Priority Techniques Evaluation
  - o Concept Report and Sketch Plan
- > Next Steps

#### Project Schedule – BRT Study

Task	Task Initiation / Due Dates	Deliverables
1.1: Concept Development	3/7/2023 6/28/2023	<ul><li>Priority Techniques Evaluation</li><li>Concept Report and Sketch Plan</li></ul>

August 30, 2023 AJ Jordan Page 13 of 13

Reference: PennDOT E05224 – Work Order 6 – LANTA BRT Study

# Appendix B BRT Concepts

Design with community in mind









































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