MTP MODERN TRANSIT Partnership

Corridor Two Regional Rail Feasibility Study and Alignment Alternatives

TECHNICAL MEMORANDUM 6.1

Rail Operations Analysis

December 2009

Gannett Fleming

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Commuter Rail Operations Planning and Feasibility Analysis

Overview and Purpose

The purpose of this operations analysis was to identify key rail operating parameters and assumptions, and to preliminarily assess the operational feasibility of providing commuter rail service in the Harrisburg-Hershey-Lebanon corridor. Based on earlier analyses that concluded that the most feasible strategy for introducing commuter rail service in the corridor would be to add a third track to the Norfolk Southern mainline, this analysis was limited to assessing the operational feasibility of that approach. The materials presented in this report were prepared by Gannett Fleming Inc.

Specific technical objectives of the analysis were twofold:

- Determine the approximate unimpeded travel time between the two terminal stations given assumed equipment (i.e., the train), assumed mid-line station stops, assumed station stop dwell times and assumed maximum operating speeds and speed restrictions;

- Develop two alternative "pro forma" Operating Plans (train schedules) that reflect a potentially feasible service and reflect operating realities including assumed vehicle fleet size, required schedule recovery time and train crewing (staffing) requirements and restrictions.

With reference to the latter, the two pro forma Operating Plans will be referenced in this document as follows:

- A "basic service" consisting of eight (8) daily round-trips on variable headways (35 minutes to 3 hours) requiring two sets of equipment (i.e., two trainsets); and,

- An "enhanced service" consisting of thirteen (13) daily round-trips on 30-minute to 100-minute headways requiring three sets of equipment.

To provide some context for these two service levels, the basic service is similar to the level of service that existed on Amtrak's Harrisburg-Philadelphia "Keystone Corridor" prior to the significant capital improvements to that line (generally prior to about 2004).

The enhanced service, at 13 round trips on weekdays, is similar to the current Keystone schedule that offers 14 weekday round trips and has attracted significantly more riders.

Ideally an analysis of this type would be conducted using actual data for existing train movements, existing right-of-way limits, and an inventory of existing structures (both overhead bridges and under-grade structures). Since that data was not available to the consultants, the study team was directed by the Modern Transit Partnership to proceed by applying a reasonable set of assumptions regarding Norfolk Southern's train operations and right-of-way that could be supported based on limited on-site observations, industry knowledge, and third party data and documents.

The proposed Operating Plans that are described in the following sections should be viewed as preliminary in nature since they were developed for purposes of performing a preliminary assessment of the operational feasibility of the proposed Corridor Two commuter rail service. The schedules will be reviewed and further refined should the project advance to engineering.

Study Approach

A specialized software package called RAILSIM® was utilized to build a Train Performance Calculator (TPC) model of the existing rail line between Harrisburg and Lebanon in both directions. The total length of run was 141,553 feet or 26.8 miles between the assumed Lebanon Station stop location at Norfolk Southern Mile Post 85.75 (vicinity of Front and Lincoln streets) and an assumed Harrisburg terminal stop at approximately the site of the existing Harrisburg Transportation Center.

Once the rail network, including the new third track, was defined and a type of rail car identified for purposes of the analysis, two alternative typical weekday operating schedules as described above were developed and tested. A weekday schedule was used for testing purposes since that is the busiest time for both freight and commuter traffic. It was assumed that if a service is feasible during the week, it should also be feasible at other times. The alternative operating schedules were evaluated for their relative abilities to serve the key travel markets and major destinations along the corridor. A risk inherent in the analysis is that no historical or nominal freight train operating data was received from Norfolk Southern, which declined to participate. Therefore, although extensive segments of new, independent track were assumed for the potential commuter rail service, there is still a possibility of interference with freight operations at specific locations where commuter service cannot exist exclusively on the additional third track. Those locations are identified in this narrative.

Finally, an overall assessment was made regarding the preliminary operational feasibility of introducing commuter rail service along the existing Norfolk Southern mainline between Harrisburg, Hershey and Lebanon.

Assumptions

As noted in the Overview, train operating data, right-of way mapping, and a structures inventory were not available from Norfolk Southern for use by the consultants. Therefore, a broader range of assumptions was required than would normally be necessary for a study of this type. The following paragraphs identify in detail the maximum operating speed, track, signalization, vehicle, operating, and facilities assumptions.

Maximum Operating Speed and Schedule Recovery Times

A maximum operating speed of 60 miles-per-hour was assumed. The resulting predicted unimpeded trip time with provision for five mid-line (intermediate) passenger Station stops -- each with a dwell time of 60 seconds -- and one operational stop of up to five minutes (to meet a train operating in the opposite direction) was fifty (50) minutes.[1] At the preliminary feasibility study stage, it is appropriate to assume a relatively generous schedule recovery margin that might be refined downward once a project moves forward to engineering design. Therefore a 10-minute schedule recovery cushion was assumed yielding a practical trip time of one hour between the two terminal stations for scheduling purposes.[2] This includes a five-minute margin to absorb the delay inherent in stopping to meet a train operating in the opposite direction, which is further explained on following pages.

Absent the five minutes allocated to certain schedules in order to meet another commuter rail train traveling in the opposite direction, the nominal terminal-to-terminal running time (with schedule recovery) would yield 26.8 miles in 55 minutes for an average speed of 29.2 miles per hour, assuming 60-second mid-line station dwells at each of four public station stops: Annville, Hershey, Hummelstown and East Harrisburg.

[1] To achieve a peak-period, peak-direction service headway of 30 minutes, utilizing a third trainset, it was necessary to assume a second operational stop for certain reverse-peak-direction trains resulting in a 57-minute trip time (not including schedule recovery time).

[2] As noted, a slightly longer trip time is required for some reverse-peak trains that are scheduled to meet two opposing trains during their trip. This applies only to a potential Operating Plan variant that features 30-minute peak-period, peak-direction service while simultaneously maintaining some reverse peak service. This requires a third trainset during peak service periods.

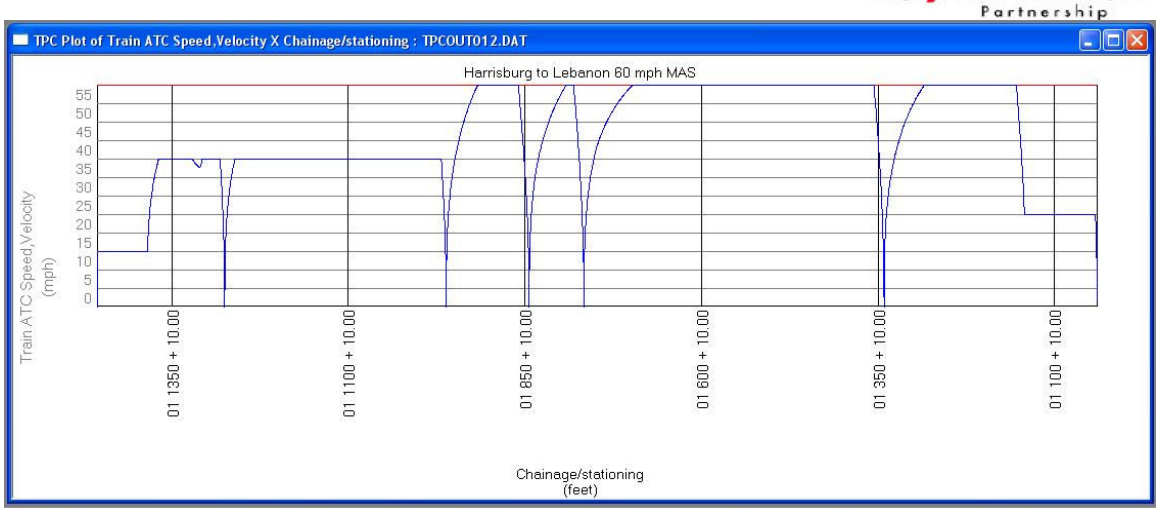

Figure 1 - Train Performance Calculator velocity profile plot of 4-unit Colorado Railcar DMU operating unimpeded from Harrisburg to Lebanon in simulation, assuming 60 mph maximum speed.

Track and Signals

The existing two-track mainline extending between Harrisburg and Lebanon (and onward to Pittsburgh to the west and to Philadelphia via Reading to the east) is owned and operated by Norfolk Southern Railway (NS), which is one of the five largest freight railroads in the United States. The center of downtown Lebanon in the vicinity of 4th Street is situated between Mile Post 86 and 87. The assumed Harrisburg station stop, i.e. the Harrisburg Transportation Center is just short of Mile Post 113.[3]

NS operates freight trains in each direction over the route daily. In addition, Rutherford Yard situated on the eastern outskirts of Harrisburg (between Mile Post 105 and 108) is an important intermodal facility with significant activity and also represents a potential impediment to possible construction of a dedicated passenger train track or tracks. Conceptual engineering was undertaken to identify locations where a dedicated third track for passenger train operations could potentially be constructed, in order to limit required access to the existing Norfolk Southern main tracks to specific locations where it could not be avoided. In some instances, existing switching leads and industrial sidings were assumed to be upgraded to appropriate standards to support the operation of commuter passenger trains, with access for freight switching retained and generally improved.

With the exception of up to two specific locations where passenger trains operating in opposite directions would meet (Mile Post 96.5 to 97.0 and Mile Post 101.0 to 102.75), the assumed new infrastructure was held to a single track in order to fit within the

[3] The NS Harrisburg Line ends 4,226 feet west of Mile Post 112 at CP Harris where it becomes the Pittsburgh Line.

existing right-of-way limits as much as possible. Even so, limited shifting (relocation) of the existing main track centerlines and some potential property acquisition would be required. This topic is addressed in more detail in the Conceptual Engineering Technical Memorandum. Passing siding locations were identified within the existing right-of-way limits and would serve a dual purpose as "meet" locations for the proposed passenger service and as improved freight switching access and 'run-around' facilities for the freight operator.

Since Norfolk Southern declined to participate in this study, all assumptions regarding Norfolk Southern train operations and right-of-way were made from observations, industry knowledge and third-party data and documents, with several exceptions listed under "Data Sources", below.

At two key locations, construction of a dedicated passenger train track was deemed to be infeasible short of very high construction costs, as follows:

- Downtown Hershey and vicinity (approximately Mile Post 98 to 100), where it was assumed that an existing third track would be improved and utilized. This track is currently used by freight trains and often there are freight cars standing it.

- Adjacent to, and just east of, Rutherford Yard at or near the site of CP Beaver (an existing Interlocking near Mile Post 104). At or near this location it would be necessary for the proposed passenger trains to cross over from the north side to the south side of the right-of-way when operating eastbound (or visa versa when westbound). A "duck under" structure is proposed to address this need and it is described in more detail in the Engineering Concepts technical memorandum.

In addition, there is no easy way to bring Corridor Two trains into the Harrisburg Transportation Center (HTC) from the Norfolk Southern Harrisburg Line. This is because NS predecessor Reading Railroad was in competition with its former rival the Pennsylvania Railroad (PRR) at Harrisburg and located its station across the tracks on the current site of the U.S. Postal facility. The Reading station was demolished in 1956 to make way for the Post Office building. This topic is addressed at a high-level in the Engineering Concepts technical memorandum; however, a separate engineering study would be required to fully assess the needed improvements and the associated costs.

Because of the horizontal and vertical alignment challenges, for purposes of this analysis it was assumed that the track connection to access HTC (or dedicated spur track to an independent station facility in the near term) would have a maximum operating speed of 15 miles-per-hour from the east limit of existing CP Capitol to end-of-track at the assumed station platform (approximately one mile). This was reflected in the TPC runs.

An existing series of speed restrictions between CP Beaver (Mile Post 105) and CP Capitol (approximately Mile Post 111.5) that vary between 30 and 35 mph was assumed to be upgraded to 40 mph for the proposed passenger trains or that a dedicated new track would be able to support 40 mph operation through this area. Furthermore, because the west limit of CP Beaver is close to the proposed Hummelstown Station, 40 mph Maximum Authorized Speed (MAS) for passenger trains was assumed to begin/end at the Hummelstown Station and extend westward to Mile Post 111.3 (east limit of CP Capitol).

All remaining track within the study territory has a nominal MAS of 50 mph for freight train operation. A limit of 60 mph was assumed for passenger trains. This should be achievable in most or all locations even under existing conditions, and therefore assumes only that the proposed new track is constructed to standards not less than that to which the existing main tracks are currently being maintained.

With regard to signals, the new track, including the anticipated one or two passing siding locations (depending on whether the basic or enhanced service plan is implemented), will probably require at least a basic 2-block, 3-aspect wayside signal system.

In addition to the above, if the passenger trains will access any portion of the existing two-track NS mainline (that will be the case unless a "jumpover" is constructed to allow the new passenger track to switch from the south side of the main to the north side just east of Rutherford yard), modifications to NS's existing signal system will be necessary at Hershey and at CP Beaver just east of Rutherford Yard

Grade crossing warning systems will clearly need to be installed, upgraded or modified on a case-by-case basis, even if no "quiet zone" applications are made. If the existing equipment in the field is relatively new and in good condition, it may be cost-effective to modify it, add or relocate gates, etc. Where a crossing might currently have no active warning system (just signage) it would almost certainly have to be upgraded if it's a public road.

Vehicles

Since vehicle performance is an important parameter for simulating rail operations, a type of vehicle and its inherent performance characteristics had to be assumed. The single-level variant of the Colorado Railcar diesel multiple-unit (DMU) vehicle was the assumed rail passenger vehicle for modeling purposes. The Colorado Railcar DMU vehicles meet or exceed current Federal Railroad Administration (FRA) buff strength (collision survivability) requirements. If further engineering and operations studies are advanced for Corridor Two, a detailed analysis of rail vehicle options would be completed and a recommended vehicle type identified at that time. (**note**: at the time of the printing of this report, the Colorado Rail Car Company had filed for bankruptcy. This does not negate the validity of this assumption since the vehicle is representative of the type of DMU that would be appropriate for the corridor, regardless of who the manufacturer might be.)

The Colorado Railcar technical materials specifically state that each powered unit is capable of pulling one or more unpowered trailer coaches. This assumption has been confirmed by demonstration on Florida's "Tri-Rail" (SFRTA) system and elsewhere.

Enhanced Service Plan (proposed for weekday service)

For the "basic" service plan, it was assumed that three (3) trainsets would be acquired for Corridor Two service. While actual consist size would be determined (based largely on expected demand) as part of more detailed operations planning leading up to the start of service, for purposes of this analysis a four-car train length was assumed This results in a conservative assumption on train speeds and total running time required to traverse the corridor, since a train of shorter length (which is likely at the start of service) could perform at or above that of the four-car consist. (*Note: Subsequent to completion of the analysis and findings described in the following sections, a decision was made to assume three-car consists based primarily on the demand forecast. The TPC model was updated with appropriate performance and other specifications for a three-car consist and new values were calculated. The result was an increase of approximately one minute in the travel time between the two terminal stations. Based on this information, the results reported below were judged to be valid since the one minute difference falls well within the assumed "pad" time and within normal margins of error and acceptable degrees of accuracy for a preliminary feasibility study. Therefore no additional re-analysis was performed. This note is included here to explain the difference between the consist assumptions reported here versus the assumptions reported in the Technical Memorandums on demand estimation and capital cost estimates.*). Each trainset would consist of four (4) total cars comprised of a powered car with control cabin at each end of the train, and two unpowered coaches positioned as the two middle cars of each train consist. Two trainsets would be required to meet peak service requirements, and the third trainset would allow one complete four-car trainset to be rotated out of service for repairs and/or scheduled inspection without affecting either the service or the capacity of the trains in service. A third trainset could also support the operation of more service, specifically the operation of a 30-minute service in the peak direction each weekday (i.e., westbound in the morning and eastbound in the evening). But to support servicing and mandatory inspection requirements, the fleet would need to be supplemented by at least one additional powered vehicle equipped with a control compartment ("cab"). Each four-car trainset would have a total seating capacity of 392 (94 passengers for each powered unit and 102 passengers for each unpowered trailer coach), according to materials circulated by the manufacturer.

Figure 2 -- A two-unit, single-level Colorado Railcar DMU

Operations

Public station stops were assumed as follows (listed in sequence east to west):

Lebanon (terminal station)
Annville
Hershey
Hummelstown
East Harrisburg
Harrisburg (terminal station).

All mid-line passenger station dwells were assumed to be of 60 seconds duration.

A full seated load (no standees) was assumed for all TPC runs.

One operational stop was assumed to occur, as needed, at a siding that would be located between Mile Post 101.0 and Mile Post 101.75 (between Hershey and Hummelstown) to meet an opposing passenger train. However, in certain instances the Operating Plan does not call for such a meet, in which case the stop is not required.

In the "enhanced" service scenario (30-minute peak headways), a few reverse-peak trains would be required to stop and meet *two* opposing trains at two different siding locations, requiring up to seven additional minutes. The second meeting point was assumed to be siding that would be constructed between Mile Post 96.5 and 97.0 (near Palmyra, between Hershey and Annville.)

It was assumed that Federal railroad "hours-of-service" law would apply to personnel operating the passenger trains. This means that their maximum workday cannot exceed twelve (12) hours. Moreover, to avoid implications of recent changes to these regulations that pertain to minimum rest between shifts and time spent waiting to be relieved (after ceasing train operation), pro forma Operating Plans (train schedules) were developed that would allow train crews to return to the terminal at which they reported for duty within the 12-hour limit and therefore either avoid deadheading or make it possible for a relieved crew to ride the scheduled passenger train service to return to their "home" terminal.

No assumption was made as to the number of train staff (i.e., specific headcount) required as this was not germane to development of pro forma Operating Plans. This topic will be addressed as part of estimating the rail operating and maintenance costs.

It was assumed that crews staffing and operating "revenue" train trips would also be responsible for operating short non-revenue trips to and from a nearby layover facility when both staff and equipment were simultaneously entering or leaving service.

It was assumed that crews would need a minimum of fifteen (15) minutes to "change ends" (reverse direction) at each terminal station and to recover from minor en route delays. This is typical. Under unusual circumstances, it may be possible for a train crew to "reverse" more quickly but such an assumption was not deemed to be appropriate as a planned operation.

To the extent feasible, every effort was made to schedule peak-period and mid-afternoon trips to attract commuters working in downtown Harrisburg and at Hershey, where a number of major employers and trip generators are located.

- The largest shift for State Capitol Complex workers is 8:00 AM - 4:30 PM and it was assumed that the Capitol Complex will be the largest attractor of commuters.

- First Shift at Hershey Foods starts between 6:00 AM and 7:00 AM and ends from 2:00 PM to 3:00 PM. Office staffs typically complete their shift at about 4 PM.

- Second shift at Hershey Foods begins from 2:00 PM to 3:00 PM and ends between 10:00 PM and 11:00 PM.

- The overnight shift at Hershey Foods begins at 10 PM and ends with the start of the First Shift (but none of the Operating Plans developed for the rail alternative contemplate late-night rail service).

It was assumed that people commuting to employment locations in downtown Harrisburg will represent the largest market segment, followed by commuters working in the Hershey area and then persons traveling to Harrisburg for other reasons. Operating

realities will make it impossible to operate service that arrives and departs at ideal times for all of these market segments throughout the day. This is particularly true given the assumed limitation of a primarily "single-track" operation. For purposes of this preliminary feasibility study, it can be assumed that if the commuter rail service is judged to be operationally feasible during peak, mid-day, and evening periods, late night service would also be feasible since fewer commuter trains would be required to meet demand. Special events at Hershey area venues and the 24-7 nature of the Hershey Medical Center are two examples where there could be potential demand for later service. These topics could be better addressed in appropriate detail during advanced studies, should they be initiated.

Facilities

It was assumed that a small layover facility would be created at or near the existing Norfolk Southern Horntown Yard to the west of downtown Lebanon at approximately Mile Post 87.4 and the site of a junction with an industrial spur track. Moreover, adjacent land use in this area is generally commercial/industrial.

For the three-trainset Operating Plan with enhanced service, it was assumed that one trainset would lay-over in Harrisburg each night at a site to be determined. This would require the availability of 480V standby power, appropriate security such as a fence or other protection, adequate lighting, and a dumpster or other basic system for trash disposal to support a simple cleaning of cars each night. It was assumed that the Harrisburg site would be at (or in very close proximity to) the assumed public passenger station stop and would not require any more substantial servicing facilities. A brake test would be required in Harrisburg before the initial run, but all fueling would occur at the Lebanon site. It was assumed that all routine servicing and inspections would also be undertaken at the Lebanon site. The two-trainset Operating Plan brings both trainsets to Lebanon each night. The three-trainset, "enhanced" Operating Plan rotates each trainset such that each finishes at Lebanon two out of every three nights.

Not considered as part of the operations planning facet of the study and not reflected in the "enhanced" Operating Plan is whether a Friday-night eastbound deadhead operation of the "Harrisburg" trainset (in a three-trainset scenario) would be desirable in order to bring it back to Lebanon and similarly, whether a Monday-morning-only westbound deadhead trip would be required in order to stage one trainset to enter revenue service at Harrisburg. These decisions would be influenced by (1) whether or not there would be any weekend service, and (2) if the service level remained within the capabilities of a two-trainset operation, this potential deadheading issue could be avoided. These types of details are beyond the scope of a preliminary feasibility study.

Data Sources

Data sources, in addition to those mentioned previously, that were used to develop the above assumptions included:

1. Track Charts, Norfolk Southern Harrisburg Line, dated June 29, 2003.
2. Conrail Employees Timetable, Harrisburg Line, dated October, 1986 (used for guidance concerning operating speed restrictions only).
3. Colorado Railcar DMU brochure dated 2005.
4. Supplemental Colorado Railcar data (current) via website download.
5. Various Google Earth searches and images along subject right-of-way and adjacent parcels.
6. Various commercial Pennsylvania street and highway maps.

Methodology

Standard methodology was employed to build a single-line TPC database for each direction. A TPC database is required for each direction because slopes of the track grades are reversed when traveling in the opposite direction along the same path.

The TPC databases included:

- Assumed station platform edge limits (i.e., lengths and locations);
- Assumed speed limits and speed restrictions already outlined;
- Assumed train composition consisting of one powered unit with control cab at each end of the train, and two unpowered coaches, as described;
- Train performance (acceleration and braking) computed from manufacturer's data for the assumed equipment and generally already programmed within the RAILSIM TPC Rolling Stock Library;
- Train physical parameters (length, width, height, cross-sectional area, weight) based on manufacturer's data and data contained in the RAILSIM Rolling Stock Library;
- Seating capacity (392 per trainset) to determine seated load based on manufacturer's data;
- Assumed operational stops (as required);
- Assumed mid-line station dwells (60 seconds).

Horizontal alignment (curve data) was not included because modest curvature such as found on the alignment of interest has a very small effect on equipment performance through flange resistance. No curve speed restrictions were identified except for the assumed potential future infrastructure to support access from the NS Harrisburg Line into the existing HTC.

Results

Tables **1** and **2**, below, present the "raw" TPC running time interval results between each station or operational stop for both the Eastbound (Table 1) and Westbound (Table 2) directions. The next adjacent column in each table displays the rounded running time interval to the next greater whole minute. The third column displays the scheduled running time assumed for the purpose of developing the pro forma Operating Plans. In keeping with generally accepted practice, more scheduled running time was applied on an

absolute basis between stations that are encountered later in the trip. However, in addition, two minutes of recovery time was allocated for the operational stop (when required) because the ability to advance beyond the operational stop depends upon the timely arrival of the opposing train.

Table 1 - Predicted Interval Running Times and Assumed Scheduled Times			
Colorado Railcar single-level DMU (4 units), 60 mph maximum speed; full seated load.			
Eastbound	**TPC Result**	**Nearest whole minute**	**Scheduled Time**
Dp. Harrisburg ***Transportation Center***	00:00.0		
Ar. East Harrisburg	08:57.5	0:09	0:10
Ar. Hummelstown	19:53.8	0:20	0:22
Ar. Operational Stop, M.P. 101.0	*24:30.3*	*0:25*	*0:27*
Dp. Operational Stop, M.P. 101.0	*29:30.0*	*0:30*	*0:32*
Ar. Hershey ***Hershey Intermodal Ctr.***	31:51.0	0:32	0:35
Ar. Annville	42:20.0	0:43	0:47
Ar. Lebanon	53:04.0	0:54	1:00

Table 2 - Predicted Interval Running Times and Assumed Scheduled Times			
Colorado Railcar single-level DMU (4 units), 60 mph maximum speed; full seated load.			
Westbound	**TPC Result**	**Nearest whole minute**	**Scheduled Time**
Dp. Lebanon	00:00.0		
Ar. Annville	09:12.7	0:10	0:10
Ar. Hershey ***Hershey Intermodal Ctr.***	19:40.0	0:20	0:22
Ar. Operational Stop, M.P. 102.75	*24:11.2*	*0:25*	*0:27*
Dp. Operational Stop, M.P. 102.75	*29:11.0*	*0:30*	*0:32*
Ar. Hummelstown	31:42.0	0:32	0:37
Ar. East Harrisburg	42:38.0	0:43	0:50
Ar. Harrisburg ***Transportation Center***	53:04.0	0:54	1:00

Similarly, two train schedules within the "enhanced" (13 trip) Operating Plan require two separate meets with opposing trains, which is not reflected in the above tables. Seven minutes was added to their scheduled running times to support the meet. An extra two minutes was allocated to absorb the second meet (5 + 2) to reflect increased operational variability arising from having to meet two trains instead of just one train.

Two Operating Plans were developed and are presented on the following pages. The "basic" eight-round-trip Operating Plan requires two trainsets to satisfy peak service requirements. It supports operation of two trips in the peak direction each morning and evening on the shortest practicable headway. But because there are only two trainsets employed – both of which must be positioned at the same terminal in order to support a peak-period scheduled headway of less than an hour – service in the reverse-peak direction is very limited during those hours. Note that it is possible to add at least one additional round-trip to the 8-trip Plan without materially extending the service day, should sufficient travel demand materialize. The "enhanced" thirteen-round-trip Plan requires three trainsets to meet peak service requirements. It would be more costly to operate but supports better service in both the peak and reverse-peak directions because there is always at least one trainset operating in the reverse-peak direction even when the other two trains are positioned to support maximum service in the peak direction (e.g., eastbound from Harrisburg during the evening commuting hours). With both plans, an effort was made to avoid requiring peak-period, peak-direction trains to stop for meets. The reverse-peak train is scheduled to stop instead.

As previously noted, the basic service is similar to the level of service that existed on Amtrak's Keystone Corridor prior to the significant capital improvements to that line. The enhanced service, at 13 round trips on weekdays, is similar to the current Keystone schedule that offers 14 weekday round trips and has attracted significantly more riders.

Figure 3 -- "Basic" Operating Plan (8 weekday round trips)

	1	1	2		2	1	2		1		2	1	2		2	< Trainset
	Crew #1 start	1	Crew #2 start		2	1	2		3		Crew #4 start	3	4		4	< Crew
Eastbound	**DH 101**	**#102**	**DH 103**		**#104**	**#106**	**#108**		**#110**		**DH 113**	**#112**	**#114**		**#116**	
Dp. Harrisburg ***Transportation***		5:30 AM			8:20 AM	10:20 AM	12:20 PM		2:00 PM			4:40 PM	5:55 PM		8:20 PM	
Ar. East Harrisburg ***Harrisburg***		5:40 AM			8:30 AM	10:30 AM	12:30 PM		2:10 PM			4:50 PM	6:05 PM		8:30 PM	
Ar. Hummelstown	DH Trainset #1 from Layover Yard to Lebanon Station, appx. 4:00 AM	5:52 AM	DH Trainset #2 from Layover Yard to Lebanon Station, appx. 6:10 AM		8:42 AM	10:42 AM	12:42 PM		2:22 PM		Possible DH of Trainset #2 from Layover Yard to Lebanon Station, appx. 4:20 PM	5:02 PM	6:17 PM		8:42 PM	
Ar. Operational Stop, M.P. 161.		---			---	*10:47 AM*	---		---			---	---		---	
Dp. Operational Stop, M.P. 161.		---			---	*10:52 AM* d	---		---			---	---		---	
Ar. Hershey ***Hershey Park***		6:00 AM			8:50 AM d	10:55 AM	12:50 PM		2:30 PM			5:10 PM d	6:25 PM d		8:50 PM d	
Ar. Annville		6:12 AM d			9:02 AM d	11:07 AM d	1:02 PM d		2:42 PM d			5:22 PM d	6:37 PM d		9:02 PM d	
Ar. Lebanon		6:25 AM			9:15 AM	11:20 AM	1:15 PM		2:55 PM			5:35 PM	6:50 PM		9:15 PM	
Turns to:	#101	#105	#103		#107	#109	DH 108		#111		#113	DH 112	#115		DH 116	< Turns to
		No Meet			No Meet	Meet #107	No Meet		No Meet			Meet #113	No Meet		No Meet	
						Crew #1 off										
	1		2	1		2	2	1		1		2	1	2	2	< Trainset
	1		2	1		2	2	*Crew #3 start*		3		4	3	4	4	< Crew
Westbound	**#101**		**#103**	**#105**		**#107**	**DH 108**	**#109**		**#111**		**#113**	**DH 112**	**#115**	**DH 116**	
Dp. Lebanon	4:20 AM		6:45 AM	7:20 AM		10:20 AM		12:40 PM		3:20 PM		4:40 PM		7:10 PM		
Ar. Annville	4:30 AM		6:55 AM	7:30 AM		10:30 AM		12:50 PM		3:30 PM		4:50 PM		7:20 PM		
Ar. Hershey ***Hershey Park***	4:42 AM		7:07 AM	7:42 AM		10:42 AM	Possible DH of Trainset #2 from Lebanon Station to Layover Yard, appx. 1:30 PM	1:02 PM		3:42 PM		5:02 PM	DH of Trainset #1 from Lebanon Station to Layover Yard, appx. 5:50 PM	7:32 PM	DH of Trainset #2 from Lebanon Station to Layover Yard, appx. 9:30 PM	
Ar. Operational Stop, M.P. 162.	---		---	---		---		---		---		*5:07 PM*		---		
Dp. Operational Stop, M.P. 162.	---		---	---		---		---		---		*5:12 PM* d		---		
Ar. Hummelstown	4:52 AM		7:17 AM d	7:52 AM d		10:52 AM		1:12 PM		3:52 PM d		5:17 PM d		7:42 PM d		
Ar. East Harrisburg ***Harrisburg***	5:05 AM d		7:30 AM d	8:05 AM d		11:05 AM d		1:25 PM d		4:05 PM d		5:30 PM d		7:55 PM d		
Ar. Harrisburg ***Transportation***	5:15 AM		7:40 AM	8:15 AM		11:15 AM		1:35 PM		4:15 PM		5:40 PM		8:05 PM		
Turns to:	#102		#104	#106		#108	*Crew #2 off*	#110		#112		#114	*Crew #3 off*	#116	*Crew #4 off*	< Turns to
	No Meet		No Meet	Meet #104		Meet #106		No Meet		No Meet		Meet #112	Done	No Meet	Done	
						Lunch break										

Notes:

(d) - Train may depart ahead of scheduled time.

Times shown in italic are operational stop only; not a stop to discharge or receive passengers.

[shaded] = Peak Period

Green shaded boxes indicate Trainset 1 (bold border) and/or Crew 1.
Yellow shaded boxes indicate Trainset 2 (bold border) and/or Crew 2.
White (unshaded) boxes with numeral indicate Crew 3 or relief Crew 4.

"DH" indicates "deadhead" (non-revenue train positioning movement).

Figure 4 -- "Enhanced" Operating Plan (13 weekday round trips)

	1	3	2	1		2	3	1	2	1	2	3	1	2	1	2	< Trainset
	Crew #1 start	Crew #3 start	Crew #2 start	1		2	3	1	2	3	1	2	Crew #4 start	5	4	5	< Crew
Eastbound	**DH 101**	**#102**	**DH 103**	**#104**		**#106**	**#108**	**#110**	**#112**	**#114**	**#116**	**#118**	**#120**	**#122**	**#124**	**#126**	
Dp. Harrisburg *Transportation Ctr.*	DH Trainset #1 from Layover Yard to Lebanon Station, appx. 5:00 AM	5:30 AM	DH Trainset #2 from Layover Yard to Lebanon Station, appx. 6:15 AM (run ahead of #102)	6:45 AM		8:15 AM	9:30 AM	10:40 AM	12:00 PM	1:20 PM	3:00 PM	4:20 PM	4:50 PM	6:00 PM	7:20 PM	8:50 PM	
Ar. East Harrisburg *Harrisburg Ma*		5:40 AM		6:55 AM		8:25 AM	9:40 AM	10:50 AM	12:10 PM	1:30 PM	3:10 PM	4:30 PM	5:00 PM	6:10 PM	7:30 PM	9:00 PM	
Ar. Hummelstown		5:52 AM		7:07 AM		8:37 AM	9:52 AM	11:02 AM	12:22 PM	1:42 PM	3:22 PM	4:42 PM	5:12 PM	6:22 PM	7:42 PM	9:12 PM	
Ar. Operational Stop, M.P. 161.6		*5:57 AM*		*7:12 AM*		*8:42 AM*	---	*11:07 AM*	*12:27 PM*	---	---	---	---	---	---	---	
Dp. Operational Stop, M.P. 161.6		*6:02 AM* d		*7:17 AM* d		*8:47 AM* d	---	*11:12 AM* d	*12:32 PM* d	---	---	---	---	---	---	---	
Ar. Hershey *Hershey Park*		6:05 AM		7:20 AM		8:50 AM	10:05 AM	11:15 AM	12:30 PM	1:50 PM	3:30 PM	4:50 PM d	5:20 PM d	6:30 PM d	7:55 PM d	9:20 PM d	
Ar. Operational Stop, M.P. 96.5		---		*7:26 AM*		---	---	---	---	---	---	---	---	---	---	---	
Dp. Operational Stop, M.P. 96.5		---		*7:32 AM* d		---	---	---	---	---	---	---	---	---	---	---	
Ar. Annville		6:17 AM d		7:39 AM d		9:02 AM d	10:12 AM d	11:27 AM d	12:47 PM d	2:02 PM d	3:42 PM d	5:02 PM d	5:32 PM d	6:42 PM d	8:07 PM d	9:32 PM d	
Ar. Lebanon		6:30 AM		7:52 AM		9:15 AM	10:25 AM	11:40 AM	1:00 PM	2:15 PM	3:55 PM	5:15 PM	5:45 PM	6:55 PM	8:20 PM	9:45 PM	
Turns to:	#101	#105	#103	#107		#109	#111	#113	#115	#117	#119	Done	#121	#123	#125	DH 126	< Turns to
		Meet #101		Meet #103 & #105		Meet #107	Meet #109	Meet #111	Meet #113	Meet #115	Meet #117	Meet #119	Meet #119	Meet #121	Meet #123	Meet #125	< Meet
											Crew #1 finish						
	1			2	3	1	2	3	1	2	1	3	2	1	2	1	2
	1			2	3	1	2	3	1	2	3	2	Crew 5 Start	4	5	4	5
Westbound		**#101**		**#103**	**#105**	**#107**	**#109**	**#111**	**#113**	**#115**	**#117**	**DH 118**	**#119**	**#121**	**#123**	**#125**	**DH 126**
Dp. Lebanon		5:30 AM		6:45 AM	7:15 AM	8:15 AM	9:30 AM	10:40 AM	12:00 PM	1:20 PM	3:00 PM	DH of Trainset #3 from Lebanon Station to Layover Yard, appx. 5:25 PM. Crew #2 off duty.	4:40 PM	6:00 PM	7:20 PM	8:50 PM	DH of Trainset #2 from Lebanon Station to Layover Yard, appx. 9:50 PM. Crew #5 off duty.
Ar. Annville		5:40 AM		6:55 AM	7:25 AM	8:25 AM	9:40 AM	10:50 AM	12:10 PM	1:30 PM	3:10 PM		4:50 PM	6:10 PM	7:30 PM	9:00 PM	
Ar. Operational Stop, M.P. 97.6		---		---	---	---	---	---	---	---	---		*4:54 PM*	---	---	---	
Dp. Operational Stop, M.P. 97.6		---		---	---	---	---	---	---	---	---		*4:53 PM* d	---	---	---	
Ar. Hershey *Hershey Park*		5:52 AM		7:07 AM	7:37 AM	8:37 AM	9:52 AM	11:02 AM	12:22 PM	1:42 PM	3:22 PM		5:09 PM	6:22 PM	7:42 PM	9:12 PM	
Ar. Operational Stop, M.P. 102.75		---		---	---	---	*9:57 AM*	---	---	*1:47 PM*	*3:27 PM*		*5:14 PM*	*6:27 PM*	---	*9:17 PM*	
Dp. Operational Stop, M.P. 102.75		---		---	---	---	*10:02 AM* d	---	---	*1:52 PM* d	*3:32 PM* d		*5:19 PM* d	*6:32 PM* d	---	*9:22 PM*	
Ar. Hummelstown		6:02 AM		7:17 AM d	7:47 AM d	8:47 AM d	10:07 AM	11:12 AM	12:32 PM	1:57 PM	3:37 PM		5:24 PM d	6:37 PM d	7:52 PM d	9:27 PM d	
Ar. East Harrisburg *Harrisburg Ma*		6:15 AM d		7:30 AM d	8:00 AM d	9:00 AM d	10:20 AM d	11:25 AM d	12:45 PM d	2:10 PM d	3:50 PM d		5:37 PM d	6:50 PM d	8:05 PM d	9:40 PM d	
Ar. Harrisburg *Transportation Cen*		6:25 AM		7:40 AM	8:10 AM	9:10 AM	10:30 AM	11:35 AM	12:55 PM	2:20 PM	4:00 PM		5:47 PM	7:00 PM	8:15 PM	9:50 PM	
Turns to:		#104		#106	#108	#110	#112	#118	#114	#116	#120		#122	#124	#126	Done	Done
		Meet #102		Meet #104	Meet #104	Meet #106	Meet #108	Meet #110	Meet #112	Meet #114	Meet #116		Meet #118 & #120	Meet #122	Meet #124	Meet #126	
						Crew #1 break	*Crew #2 break*	*Crew #3 break*			*Crew #3 finish*	*Crew #2 finish*				*Crew #4 finish*	*Crew #5 finish*

Notes:

(d) - Train may depart ahead of scheduled time.

Times shown in italic are operational stop only; not a stop to discharge or receive passengers. = peak period

Green shaded boxes indicate Trainset 1 (bold border) and/or Crew 1.
Yellow shaded boxes indicate Trainset 2 (bold border) and/or Crew 2.
White (unshaded) boxes with numeral indicate Trainset 3 (bold border), Crew 3 or relief Crew 4.
Pale Green shaded boxes indicate relief Crew 5.

"DH" indicates "deadhead (non-revenue train positioning movement).

As identified under "Assumptions", both Operating Plans attempt to address the Harrisburg and Hershey commuter markets as the highest priorities. Accordingly, the "basic" Operating Plan features two morning peak-period trips that are scheduled to arrive in Harrisburg at 7:40 and 8:15 AM. The "enhanced" Operating Plan features Harrisburg arrivals at 7:40 and 8:10 AM, and adds an early-bird arrival at 6:25 AM and a later arrival at 9:10 AM. In the evening, the "basic" Operating Plan offers Harrisburg departures at 4:40 and 5:55 PM, while the "enhanced" Plan utilizing three trainsets offers *three* peak-period Harrisburg departures: at 4:20 PM, 4:50 PM, 6:00 PM, and an evening departure at 7:20 PM. All of these trains in both Operating Plans stop at Hershey and at all other Stations.

Providing ideal service to Hershey presents somewhat of a challenge given the assumption of a single-track infrastructure. As a result, service at Hershey is more attractive in the "peak" direction (toward Harrisburg in the morning, and toward Lebanon in the evening) than it is in the reverse-peak direction. This is unavoidable absent a much larger investment in rolling stock, infrastructure, and operating costs. The "basic" 8-trip Operating Plan offers westbound (peak direction) service to Hershey at 7:07 and 7:42 AM, but in the eastbound direction (reverse-peak) there is a gap in service from 6:00 AM until 8:50 AM. Adding a third trainset and a second available siding for train meets yielded a 7:20 AM eastbound arrival at Hershey with the "enhanced" Operating Plan while retaining both of the other two schedule choices (6:05 AM and 8:50 AM). In the westbound direction, the "enhanced" Plan features four morning arrival time choices at Hershey: 5:52, 7:07, 7:37 and 8:37 AM (plus 9:52 and 11:02 AM that are well beyond First Shift starting times).

In the afternoon, the "basic" Plan offers only a 2:30 PM eastbound departure from Hershey with service to Annville and Lebanon, with a significant gap in eastbound service thereafter until 5:10 PM. The "enhanced" Plan by contrast offers twice as much mid-afternoon eastbound service (1:50 and 3:30 PM departures), followed by the first of three evening-peak westbound trains beginning at 4:50 PM (followed in turn by additional choices at 5:20 and 6:30 PM. The enhanced Plan also offers evening service at 7:55 PM, and a final trip scheduled to stop at Hershey at 9:20 PM.

Passengers seeking westbound transportation from Hershey toward Harrisburg in the mid-to-late afternoon have two choices in the "basic" Operating Plan: 3:42 PM and 5:02 PM. The last opportunity is at 7:32 PM. By contrast, the "enhanced" Operating Plan includes westbound departures from Hershey at 1:42 and 3:22 PM, followed by two peak-period trains scheduled to stop at 5:09 and 6:22 PM. The enhanced Plan offers evening service at 7:42 PM, plus a final opportunity at 9:12 PM.

Both of the planning-stage Operating Plans presented above include potential daily non-revenue equipment positioning schedules that would be required to move trains from a potential layover facility at or near Lebanon into (or away from) the Lebanon Station.

Conclusions

The operations analysis and planning for the rail alternative utilizing the existing Norfolk Southern Harrisburg Line alignment capitalized on a rail alternatives evaluation which concluded that construction of an additional single track adjacent to the existing double-tracked NS mainlines is the alternative with the highest probability of physical, operational and economic feasibility. It is known that there are several particularly challenging locations from a physical feasibility and cost standpoint. This would mean that the operation of proposed commuter rail trains could take place substantially (but not entirely) without utilizing the existing NS main tracks. By the same token, this would mean a substantially single-track type of operation, with limited opportunities for meets or overtakes. Relaxation of these restrictions would require access to additional segments of the NS main track, and/or financing and execution of additional land takings in order to widen the rail corridor to accommodate four tracks with sufficient horizontal clearance between track centers to satisfy NS and Public Utility Commission requirements.

The two planning-level Operating Plans that were developed and tested would be operationally feasible providing the following conditions can be satisfied:

- a third track can be provided along the NS Main between Lebanon and Harrisburg;
- two particularly challenging physical constraints (1) at the Hershey intermodal station, and (2) in establishing an appropriate and cost-effective approach for terminating trains in the vicinity of the Harrisburg Transportation Center; and
- constructing a duck under east of Rutherford Yard to permit passenger trains to move from the north side of the NS main to the south side (when travelling east, or vice versa if travelling west) without disrupting NS freight movements.

The initial levels of service indicated by each Operating Plan are viewed to be sufficient to accommodate the anticipated ridership. Both Operating Plans would permit limited expansion as ridership grows without accessing additional segments of existing NS main track. This includes a reasonable train staffing solution that is consistent with Federal hours-of-service guidelines for railroad operating personnel and modest assumptions with regard to the acquisition of rolling stock.

As noted previously, the proposed Operating Plans should be viewed as preliminary in nature since they were developed for purposes of performing a preliminary assessment of the operational feasibility of the proposed Corridor Two commuter rail service. The schedules will be reviewed and further refined should the project advance to engineering.