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Abbreviations and Acronyms

Symbol	Description	Symbol	Description
ACE	Advanced Conceptual Engineering	MOW	Maintenance of way
ADA	Americans with Disabilities Act	MPH	Miles per hour
AHJ	Authority having jurisdiction	MTA	Metropolitan Transportation Authority
APPROX	Approximate	NEC	Northeast Corridor
MISC	Miscellaneous	NFPA	National Fire Protection Association
ARC	Access to the Region's Core	NJT	New Jersey Transit
ARCH	Architect(ural)	NO	Number
AVE	Avenue	NRT	North River Tunnels
BLDG	Building	NTS	Not to scale
BLK	Block(ing)	NYC	New York City
LIRR	Long Island Rail Road	NYCBC	New York City Building Code
BLVD	Boulevard	NYCT	New York City Transit
DIA	Diameter	O&M	Operations and maintenance
DC	Degree of curvature	OC	On center
DEIS	Draft environmental impact statement	OP	Operations
DIM	Dimension	PCIP	Penn Station Capacity Improvements Project
DSS	Double slip switch	PSCE	Penn Station Capacity Enhancement
DIV	Division	PSE	Gateway Penn Station Expansion
DOB	The Department of Buildings	PSI	Pounds per square inch
DWG	Drawing	PSNY	New York Penn Station
EIS	Environmental impact statement	QTY	Quantity(ies)
FRA	Federal Railroad Administration	RC	Radius of centerline of the curve
FT	Foot or feet	RH	Right hand
H/HT	High or height	ROD	Record of decision
HRT	Hudson River Tunnels	ROW	Right-of-way
HSR	High speed rail	RR	Railroad
HT	Height	SQ	Square
IN	Inch or inches	ST	Street
LC	Length of curve	STA	Station
LH	Left hand	SYS	System
MAINT	Maintenance	THE	Trans-Hudson Express
MAX	Maximum	TK	Track
MIN	Minimum	TO	Turnout
MECH	Mechanical	TPH	Trains per hour

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Executive Summary

Penn Station, New York (PSNY), the main intercity railroad station in New York City (NYC) and the busiest station in the U.S., serves more than 600,000 passengers per weekday. PSNY opened in 1910 and was designed at the beginning of the 20th Century in an era with considerably different railroad technology and considerably different transportation demands. During the past hundred years limited operational and infrastructure modifications have been implemented to improve the capacity and the overall condition of the station; however, these upgrades have not been sufficient. There is a critical need for significant capacity and reliability improvements at PSNY to meet existing and projected future passenger and transit demand.

Beginning in 1994, the Access to the Region's Core (ARC) Major Investment Study researched, analyzed, and short-listed a set of basic alternatives to increase trans-Hudson rail capacity. The ARC alternative chosen for advancement to construction included a new six-track station under 34th Street to augment the existing PSNY capacity. While the ARC project was eventually cancelled, development of additional rail capacity near PSNY remains a critical need, both to provide operating flexibility and resiliency and to address current and future capacity demands. This need for additional PSNY capacity is consistent with the recent NEC Future Tier I EIS for Northeast Corridor (NEC) Improvements as documented in the FRA's Record of Decision (ROD) issued in July 2017.

Amtrak is working to bring its assets to a state of good repair for improved reliability and performance, but those efforts may reduce allowable NJ TRANSIT train volumes in the near term as the East River Tunnels are rehabilitated since movements to and from Sunnyside Yard may be curtailed. Furthermore, near-term planned maintenance projects necessary to ensure safe and reliable rail operations will exacerbate the current situation, specifically, the replacement of the "U" and "M" ladders. Amtrak has also been advancing plans for the Gateway project since 2011, which would significantly increase trans-Hudson capacity and PSNY capacity with two new tunnels and the addition of eight new platform tracks. Unfortunately, the most certain element of the Gateway project is the new trans-Hudson tunnels, which would leave NJ TRANSIT platform capacity unchanged. The station expansion plans must still be subject to planning and environmental reviews and are likely to take 10 years or more to complete if approved. Meanwhile the need for more capacity, flexibility, and reliability at PSNY continues to grow and service quality has and will continue to suffer.

The urgent NJ TRANSIT need for PSNY capacity and reliability enhancements and the concerns regarding the PSE concept motivated NJ TRANSIT to undertake the Penn Station Capacity Improvement Project (PCIP). The goals and objectives of this exploratory planning effort are:

- Explore and define feasible infrastructure and operational alternatives to improve rail capacity and reliability in or adjacent to PSNY in the near term.

- Determine the feasibility of an incremental investment approach to provide capacity relief in the near term while planning, funding, and construction is in progress for the larger Gateway initiatives.
- Conceptually develop and evaluate the selected infrastructure and operations alternatives to allow NJ TRANSIT management to make further judgements about the future course of action regarding advancing planning for increased trans-Hudson rail capacity.

This Draft Final Report documents the work completed by the LTK & Arup team and presents the results of the PCIP Study. In addition to the seven review and coordination workshops organized with NJ TRANSIT, this conceptual Study also organized a workshop towards the end of the project with representatives from Amtrak and their consultants involved in the PSE concept to present the result of this work and obtain their feedback.

The PCIP planning and conceptual design effort identified, gathered, and reviewed the main existing constraints and planned projects in and around PSNY, as well as proposals for capacity expansion and other improvements at PSNY. The information gathered provided a detailed picture of the PSNY complex and surrounding built environment. The relevant information obtained was documented in the PCIP Document Catalog, a basic database of information for NJ TRANSIT that could support future efforts. Furthermore, the PCIP project developed a base map of the study area using compiled survey files, engineering plans, and as-built drawings received from different completed and on-going projects to create a conceptual 3D model of PSNY. This 3D model will help NJ TRANSIT to better understand and communicate the major existing spatial constraints in current and future planning efforts and in coordination with other stakeholders.

Using the information gathered and the 3D model developed, the PCIP project developed alternatives focused on NJ TRANSIT's near-term needs. Based upon the space constraints imposed by the existing and planned physical built environment identified through the effort, the range of potentially feasible infrastructure alternatives (that will expand NJ TRANSIT track and platform capacity at PSNY in the near term) were considerably limited.

The PCIP Team also worked with NJ TRANSIT to create a defensible approach to the development and evaluation of alternatives that allowed for informed decision making. The approach developed is quantitative and objective where possible, allows for incorporation of professional judgement where required, and provides a consistent level of development of alternatives considered within project schedule and budget constraints. The resulting alternatives development and evaluation method allowed for screening of alternatives, evaluation of project impacts and benefits, and selection of alternatives that should advance to further study.

The project identified 14 infrastructure and three operations alternatives with the potential to improve PSNY capacity and developed those alternatives to a highly conceptual level. The infrastructure alternatives evaluated generally fall into three distinct categories: (1) those that could add capacity prior to the completion of the Hudson River Tunnels (HRT), (2) those that would require the new HRT infrastructure before any benefits can be achieved, and (3) those that could provide benefits both in the near term and after the completion of the HRT project.

The proposed alternatives were then subjected to a preliminary evaluation with a focus on spatial feasibility, ability to comply with Amtrak and NJ TRANSIT design criteria, and compatibility with the project goals and objectives.

Preliminary Development and Evaluation of Alternatives

The preliminary development and evaluation of alternatives resolved the feasibility of long considered potential capacity improvements to PSNY based on conventional design standards and existing spatial constraints. The PCIP Study concluded that building tail tracks under 31st street by extending Tracks 1-4 to the east beyond 6th Avenue is not feasible. The PCIP Study also concluded that building a new platform south of Track 1 without impacting the buildings on Block 780 is not feasible.

Based on the application of the preliminary screening and evaluation method and the input obtained from NJ TRANSIT, the PCIP team selected and further developed and evaluated four infrastructure and two operations alternatives with the potential to provide capacity and reliability improvements in the near term. The selected alternatives were further advanced to a level of detail sufficient to support NJ TRANSIT decisions regarding which alternative or group of alternatives, if any, should be advanced.

The PCIP study also identified three conceptual alternatives that could provide considerable additional PSNY capacity. These alternatives included building a new deep-level terminal below PSNY served from a revised HRT bellmouth design (Alt 6), building a new 31st Street terminal east of 6th Avenue by eliminating Track 1 (Alt 9), and building a new 34th Street terminal, based on the ARC project, with a revised HRT bellmouth design (Alt 10). These three conceptual alternatives are recommended to become part of a future study of alternatives to add significant PSNY/NYC capacity after the proposed new HRT are in place since they would be long-term, capital-intensive alternatives that would not satisfy the primary PCIP Study goal of identifying potential near-term capacity gain approaches.

Selected Infrastructure Alternatives

The four infrastructure alternatives selected to advance under the PCIP Study were grouped and compared based on the conceptual improvements that they propose.

- Two infrastructure alternatives to build a new platform south of Track 1 that are compatible with current plans for the new HRTs:
  - Build new platform and two tracks under 31st Street and the northernmost part of Block 780 (Alt 12), and
  - Build the northernmost platform and two tracks of the Amtrak Penn Station Expansion (PSE) concept (Alt 13). This could be considered the initial phase of Amtrak´s Draft of Penn Station Expansion (PSE) concept.
- Two infrastructure alternatives to extend Tracks 1-4 and Platforms 1 and 2 to support longer trains that are compatible with current plans for the new HRTs:
  - Westward extension of Platforms 1 and 2 (Alt 14), and

- PSCE - Eastern and western extension of Tracks 1-4 (Alt 15). Previously developed to 30% under the Penn Station Capacity Enhancement (PSCE) Project.

To provide a potential approach to incremental investment that would improve capacity at PSNY, the PCIP Study developed the track layout for the westward extension of Platforms 1 and 2 (Alt 14) and the new platform (Alt 12) in combination to ensure that the alternatives are compatible and that they both could be advanced. An important element of the design for this combined alternative is that the westward extension of Platforms 1 and 2 requires that Tracks 1-3 no longer be connected to the "U" and "M" Ladders and would instead connect to new "T" and "R" Ladders. These new "T" and "R" Ladders would provide access to the existing "X" Tracks and, therefore, to both the existing North River Tunnels (NRT) and the planned HRT under the current HRT design.

Building a new platform under 31st Street as proposed in Alt 12 and 13 would provide meaningful additional train, platform and track capacity at PSNY and an opportunity to provide new pedestrian access and vertical and horizontal circulation. Moreover, these concepts would potentially support 2&1 operations to rehabilitate the NRT (post HRT completion). The proposed new platform in Alt 12 would be located directly south of Track 1 and in the same east/west location as the existing PSNY platforms. The proposed new platform location would avoid major impacts on the historic St. John the Baptist Church, the Affinia hotel, and the 7th Avenue Subway, which are required with Alt 13. In addition, Alt 12 would build a new concourse located above the new platform that would provide connection to and improve circulation between the Exit Concourse, the planned extension of the Central Concourse, and the NJ TRANSIT East End Concourse. Furthermore, the new platform would also be connected to an extension of the West End Concourse and to new entrances south of 31st Street.

Extending Platforms 1 and 2 as proposed in Alts 14 and 15 would provide additional trans-Hudson seat capacity, greater flexibility for platform assignments, and a potential reduction of current operational conflicts. In addition, these conceptual alternatives would provide a new connection between Platforms 1 and 2 to the West End Concourse. As with the combined alternative, the track alignment proposed in Alt 14 would disconnect Tracks 1-3 from the "U" and "M" Ladders to enable their westward extension and would connect them to new "T" and "R" Ladders that would provide access to both the existing NRT and the planned HRT. The westward extension of platforms 1 and 2 proposed (Alt 14) would allow these platforms to support 12-car train consists without having to underpin the 7th Avenue Subway or impact the 11 Pennsylvania Plaza building, which were part of the scope of the PSCE alternative (Alt 15) and would provide new pedestrian connections to an extension of the West End Concourse and the Exit Concourse.

Both Alt 12 and 14 would require significant modifications to the existing track layout and platforms at PSNY, including the realignment and removal of several tracks in "D" and "E" Yards, reconfiguration of sections of Platforms 1 and 2, and removal of the Diagonal Platform. The new trackways would also require the relocation of numerous columns within the Farley Building footprint. In addition, the westward extension of Platforms 1 and 2 (Alt 14) would require the relocation of several columns that support 8th Avenue and the 8th Avenue Subway. Building the new platform (Alt 12) would require the complete removal of approximately 1,100

linear feet of the south retaining wall and underpinning the 8th Avenue Subway and several buildings on the north section of Blocks 780 and 754.

Since these two alternatives would not be compatible with the Amtrak PSE concept as currently designed, this effort also developed a conceptual track alignment for a revised PSE concept that could be implemented in combination with proposed alternatives, 12 and 14.

Infrastructure alternatives Alt 13 and 15, while already developed outside of this project, were included in the Phase 2 evaluation for comparison purposes. Minimal modifications were performed to the track layout proposed in these two alternatives; therefore, it is expected that if these two alternatives are advanced, their track alignment and track connections would be revised and optimized.

The two infrastructure alternatives developed in the PCIP study, Alt 12 and Alt 14, were evaluated and compared to alternatives previously developed, namely the construction of one new platform as an initial phase of the PSE concept (Alt 13) and the PSCE extension of Tracks 1-4 (Alt 15) respectively. Order-of-magnitude cost estimates and conceptual schedules, both found in Appendix C, were prepared to support the multicriteria evaluation process. The order-of-magnitude cost estimate for the alternatives that proposed to build a new platform, Alts 12 and 13, are approximately $767 Million and $794 Million respectively and the total duration to complete these projects was estimated at approximately seven years for Alt 12 and eight years for Alt 13. Regarding the extension of Platforms 1 and 2, the order-of-magnitude cost estimate for Alt 14 is approximately $252 Million while for Alt 15 it is approximately $278 Million. The total estimated duration to implement these alternatives is approximately five years for Alt 14 and four and a half years for Alt 15. These order-of-magnitude cost estimates are exclusive of costs associated with real estate acquisition, buildings demolition and underpinning, rolling stock costs and finance costs and include the projected escalation to midpoint of construction for each respective alternative. If these were included, the final project costs are expected to be significantly higher.

As part of the PCIP Study, a “parallel moves” analysis was performed on combinations of the infrastructure alternatives, including the potential future PSE to assess their parallel moves capabilities to support simultaneous movement to and from New Jersey. The results of this analysis indicated that the alternatives selected would provide a track layout that would support between 92% and 94% of all possible parallel moves depending on the specific alternative, compared to the 99% of parallel moves supported by the existing “U” & “M” Ladders.

The results of the overall evaluation analysis indicated that while the implementation of any of the infrastructure alternatives considered would be challenging and would result in disruptions to service and impacts, there are feasible options to improve capacity at PSNY in the near-term. The evaluation analysis rated the proposed westward extension of Platforms 1 and 2 developed in the PCIP Study (Alt 14) higher than the platform extensions proposed in the PSCE project (Alt 15). This was due to the longer train consists and additional passenger capacity that would be supported, the improved connection to the West End Concourse provided, and the elimination of impacts to systems facilities beyond the eastern limits of the existing platforms, and to the 7th Avenue Subway and the 11 Pennsylvania Plaza Building.

Despite the higher expected impact to operations during implementation and the significant modifications on the existing track layout, the proposed alternative to build a new platform developed in the PCIP Study (Alt 12) was rated higher than the initial phase of the Amtrak PSE design (Alt 13). This was mainly due to the reduced constructability challenges, better design criteria compatibility, and the location of the new platform, which reduced impacts to existing historic buildings and the 7th Avenue Subway.

Operations Alternatives

Regarding the operations alternatives, the two selected alternatives would improve capacity with relatively small infrastructure modifications and could be implemented in the near term, with or without the new HRTs.

The two selected operations alternatives are:

- Alt OP1: Reduction of the minimum NJ TRANSIT revenue-to-revenue train dwell time to 18 minutes, and
- Alt OP2: "X" Tracks improvements to increase maximum entering speed from 15MPH to 30MPH.

The reduction of the minimum NJ TRANSIT revenue-to-revenue turn time from the current 22 minutes to 18 minutes (Alt OP1) could increase platform capacity by 17% (from a combined Amtrak/NJ TRANSIT 26 TPH to a combined 30TPH) based on the track assignment analysis conducted. The proposed reduction on the existing dwell time was determined in close coordination with NJ TRANSIT and was based on observations of routine practices, common challenges and problems related to reliability and station crowding, and incident management. The analysis conservatively assumed that no two revenue trips would alight on the same platform within five minutes of one another to reflect the recognition that limited passenger vertical circulation improvements were likely in the near term.

Based on documentation of trans-Hudson tunnel capacity through separate studies, and the PSNY Terminal Capacity high-level analysis performed as part of this study, the proposed new HRT would be required to realize the terminal capacity gain that would be provided by the proposed reduction of the minimum NJ TRANSIT revenue-to-revenue train dwell time. Without HRT, the terminal capacity gain possible with reduced revenue-to-revenue dwell time could not be realized given the 24 TPH trans-Hudson capacity limitation of the existing NRT; however, the reduction in NJ TRANSIT revenue-to-revenue turn time would provide an available terminal capacity gain that would improve both reliability and recoverability in the event of train delays.

The "X" Tracks improvements proposed (Alt OP2) would replace the existing No. 10 turnouts near the NRT portal with No. 12 turnouts and would extend ACSES II PTC coverage to the normally eastbound X tracks – 1X, 2X, and 3X to allow for increased approach speeds of 30 MPH (dropping to a target speed of 15 MPH once trains entered the "X" Tracks). It is estimated that this would enable an increase in the practical capacity of the existing NRT eastbound volume by 2 TPH to a total of 26 TPH and would likely have a positive impact on reliability. Considering that the current platform capacity at PSNY has been estimated at 26

TPH based on current scheduled minimum turn times, the implementation of the "X" Tracks improvements would realize an overall capacity gain of 2 TPH. The feasibility and issues associated with the PTC implementation would require further review.

A PSNY terminal capacity preliminary analysis was also carried out to compare the platform capacity benefits anticipated for the proposed infrastructure-oriented alternatives with the trans-Hudson capacity achievable under operations alternatives with and without HRT. The main key findings of this analysis were that:

- If the 18-min revenue-to-revenue turn time alternative (Alt OP1) is advanced, then one additional maximum length track (such as Track 10) would be available for additional flexibility and enhanced reliability. Moreover, the number of new platforms required in the long term to meet NRT and HRT trans-Hudson capacity would be reduced.
- If the X-Tracks Improvements alternative is advanced (Alt OP2) and the 22-minute revenue-to-revenue turn time is maintained, the overall capacity (considering trans-Hudson and PSNY Terminal capacity) would increase by 2 TPH (to a total of 26 TPH from the current 24 TPH). While no new platform edges would be required to meet the increased NRT trans-Hudson capacity, existing spare platform track availability would be eliminated.

It is anticipated that the two operations related alternatives considered would be easier to implement than the infrastructure alternatives, primarily because there would be no impacts to adjacent properties and relatively minor capital costs. Nevertheless, the 18-minute revenue-to-revenue dwell time alternative would require considerable changes to existing operating practices with significant recurring costs for Operations and Maintenance staffing at NJ TRANSIT. The "X" Tracks improvements proposed would have a considerable impact to train operations during implementation due to the critical area of construction and would require complex eastward expansion of the existing Amtrak ACSES II Positive Train Control (PTC) system. Implementation of either of the operational alternatives would require significant effort to secure internal stakeholder buy-in. Further, the relatively modest NJ TRANSIT capacity gains would be subject to negotiations with Amtrak regarding how the additional train slots are allocated between the two rail carriers.

Conclusions and Next Steps

The PCIP exploratory planning effort has identified feasible conceptual alternatives that could be pursued to provide a modest amount of PSNY capacity gains and improved reliability in the near-term while planning, funding, and construction is in progress for the larger Gateway initiatives and possible significant capacity expansion of PSNY.

If implemented, the PCIP proposed infrastructure and operational alternatives could provide 2 additional TPH before construction of the proposed HRT and significant trans-Hudson seat capacity, operational flexibility, and reliability benefits. Further, if advanced, these alternatives could allow for longer trainsets and increased operational flexibility and provide for as many as 10 additional TPH once the proposed HRT are in place with the addition of only two new platform edges. Moreover, these alternatives could support rehabilitation of the existing NRT

once the HRT are in place; without development of these alternatives, there would be no increase in PSNY capacity once the HRT are in place.

Combined Benefits of PCIP Proposed Infrastructure and Operational Improvements			
- Extend Platforms 1 and 2 **- New Platform A** **- 18 Min Turn Time** **- X-Tracks Improvements**	**Operating Configuration**	**Estimated Added TPHs**	**Other Benefits**
	NRT	2	Additional seat capacity and improved reliability and flexibility
	1 NRT + HRT or NRT + HRT	10	Additional train and seat capacity

NJ TRANSIT operations to and from PSNY suffer from overall capacity constraints well below demand, poorly configured platforms and vertical circulation, and poor reliability due to the state of good repair of existing track and systems. Planned replacement of the existing "U" and "M" ladders and rehabilitation of the East River Tunnels is expected to significantly worsen the situation. While new HRT are planned, there would be no increase in NJ TRANSIT capacity and PSNY once they are in place unless the PCIP or other PSNY expansion alternatives are advanced. For these reasons, it is critical that the PCIP recommendations be advanced for further consideration. Near term alternatives for PSNY capacity enhancements are required to reduce impact to rail operations anticipated from planned maintenance projects to the extent possible and to position PSNY to immediately capitalize on the new trans-Hudson capacity that will be made available once the HRT are in place.

While the modifications proposed to existing infrastructure and current operations offer significant potential benefit, implementing them would have significant impacts and costs and would require a rigorous approvals process. Further study, analysis, and coordination with project stakeholders is required and recommended to refine the engineering, constructability, and accrued train/passenger capacity gains to properly consider implementation requirements. The PCIP Study has shown that the potential significant benefit the proposed alternatives offer warrants this additional study specially when considering the critical need for NJ TRANSIT capacity improvements at PSNY in the near term. The recommendations from the study include a potential roadmap of the next steps that could be taken to advance the development of the proposed alternatives. Those next steps are outlined below.

- Perform focused modeling and micro operation simulations of the selected alternatives proposed in this Study to gain a better understanding of the potential performance of the alternatives and to more accurately estimate potential capacity benefits.
- Continued coordination with Amtrak, its consultants, and other relevant stakeholders to gather input as appropriate on the alternatives developed within the PCIP Study and, more importantly, to ensure that NJ TRANSIT interests are properly considered in their project planning.

- Develop of 10% conceptual engineering design for the preferred infrastructure alternatives identified in the PCIP Study, Alts 12 and 14.
- Assess and evaluate the benefits of implementing both infrastructure alternatives proposed (Alt 12 and Alt 14) in combination to maximize potential near-term capacity increases at PSNY.
- Evaluate implementation requirements associated with reducing the NJ TRANSIT minimum revenue-to-revenue turn time to 18 minutes as proposed in Alt OP1. Develop estimate of additional O&M costs incurred and study cost-benefit tradeoff against capacity and reliability benefits gained.
- Develop 10% conceptual engineering design for the "X" Tracks improvements (Alt OP2). Evaluate feasibility of the eastward extension of ACSES II PTC to the "X" Tracks.
- Review, study, and coordinate with Amtrak and NJ TRANSIT to assess the feasibility of restoring a bellmouth into the HRT design. Develop a bellmouth configuration that provides the most flexibility to add significant capacity near PSNY.
- Review and further develop the longer-term alternatives identified in the PCIP Study including:
    - A potential new two-platform-level, four-track stack station under 31st Street with connection to a redesigned bellmouth on the proposed HRT approach to PSNY. The lower level of this new complex would allow for extension to Queens to support potential through-running operations.
    - A potential deep-level station located near PSNY or North and East of PSNY with connection to a redesigned bellmouth on the proposed HRT approach to PSNY.
- Study of potential alternative project delivery approaches and funding mechanisms to advance the projects identified in the PCIP study.
- Study impacts of PTC on overall train operation at PSNY and its approaches.

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1 Introduction

Penn Station, New York (PSNY), the main intercity railroad station in New York City (NYC) and the busiest station in the U.S., serves more than 600,000 passengers per weekday. PSNY opened in 1910 and was designed at the beginning of the 20th Century in an era with considerably different railroad technology and considerably different transportation demands. During the past hundred years limited operational and infrastructure modifications have been implemented to improve the capacity and the overall condition of the station; however, these upgrades have not been sufficient. There is a critical need for significant capacity and reliability improvements at PSNY to meet existing and projected future passenger and transit demand.

Beginning in 1994, the Access to the Region's Core (ARC) Major Investment Study researched, analyzed, and short-listed a set of basic alternatives to increase trans-Hudson rail capacity. The ARC alternative chosen for advancement to construction included a new six-track station under 34th Street to augment the existing PSNY capacity. While the ARC project was eventually cancelled, development of additional rail capacity near PSNY remains a critical need, both to provide operating flexibility and resiliency and to address current and future capacity demands. This need for additional PSNY capacity is consistent with the recent NEC Future Tier I EIS for Northeast Corridor (NEC) Improvements as documented in the FRA's Record of Decision (ROD).

Amtrak is working to bring its assets to a state of good repair for improved reliability and performance, but those efforts may reduce allowable NJ TRANSIT train volumes in the near term as the East River Tunnels are rehabilitated since movements to and from Sunnyside Yard may be curtailed. Furthermore, near-term planned maintenance projects necessary to ensure safe and reliable rail operations will exacerbate the current situation, specifically, the replacement of the "U" and "M" ladders. Amtrak has also been advancing plans for the Gateway project since 2011, which would significantly increase trans-Hudson capacity and PSNY capacity with two new tunnels and the addition of eight new platform tracks. Unfortunately, the most certain element of the Gateway project is the new trans-Hudson tunnels, which would leave NJ TRANSIT platform capacity unchanged. The station expansion plans must still be subject to planning and environmental reviews and are likely to take 10 years or more to complete if approved. Meanwhile the need for more capacity, flexibility, and reliability at PSNY continues to grow and service quality has and will continue to suffer.

The urgent NJ TRANSIT need for PSNY capacity and reliability enhancements, as well as concerns regarding the scope and timing of the PSE concept, motivated NJ TRANSIT to undertake the Penn Station Capacity Improvement Project (PCIP). This exploratory planning effort focused on identifying an incremental investment approach that could deliver additional capacity in the near term while not precluding more significant capacity gains over the long term. Therefore, this study developed and analyzed improvements that could allow for increased passenger capacity at PSNY and that are physically and operationally compatible with the current proposal for providing two new tracks under the Hudson River and

rehabilitation of the existing North River Tunnel tubes that are part of the larger Gateway Program. Concepts identified through the PCIP Study could then potentially be advanced to provide relief in the near to medium term while planning, funding, and construction proceeds for the longer term and more costly PSE.

The specifics goals and objectives of this exploratory planning effort are:

- Explore and define feasible infrastructure and operational alternatives to improve rail capacity and reliability in or adjacent to PSNY in the near term.
- Determine the feasibility of an incremental investment approach to provide capacity relief in the near term while planning, funding, and construction is in progress for the larger Gateway initiatives.
- Conceptually develop and evaluate the selected infrastructure and operations alternatives to allow NJ TRANSIT management to make further judgements about the future course of action regarding advancing planning for increased trans-Hudson rail capacity.

For the purpose of this conceptual effort, near-term projects are those that can potentially be implemented within the next five to 10 years. This draft report refers to projects that would potentially require longer implementation durations as long-term projects.

With these objectives in mind, this conceptual planning study was divided into the following seven tasks that were completed by the consulting team formed by LTK, Arup, SSA, Envision, and Matrix in close collaboration and coordination with NJ TRANSIT.

- Task One: Inventory and review of existing conditions information.
- Task Two: Development of study base map and information graphics.
- Task Three: Development of approach to alternatives development and alternatives evaluation.
- Task Four: Development of infrastructure and operations related capacity enhancement alternatives.
- Task Five: Evaluation of alternative concepts.
- Task Six: Development of the study conclusions report.
- Task Seven: Coordination, meetings, and progress reporting.

As part of Task Seven, this effort prepared seven review and coordination workshops with NJ TRANSIT and also, towards the end of the Study, an additional workshop was organized with representatives from Amtrak and their consultants involved in the PSE concept to present the result of this work and obtain preliminary feedback. This Draft Final Report describes and documents the work completed and presents the results of the New York Penn Station Capacity Improvements Project, the PCIP.

2 Inventory and Review of Existing Conditions Information (Task 1)

The Study Team gathered, organized, and reviewed relevant existing documents available in Arup, LTK, and Matrix New World offices, the documentation provided by NJ TRANSIT, NYCT archive information, and other documentation obtained specifically for this study.

Management of the data gathered and focusing data collection on the information most relevant to the PCIP Study, were important for this Study. The Study Team compiled a significant volume of information regarding the built environment surrounding PSNY as well as relevant PSNY improvement and development plans. To ensure that the work efforts of this Task Assignment truly provided value to NJ TRANSIT in future efforts, and to facilitate the organization and access of the documentation gathered, a basic database of information was developed; the PCIP Document Catalog.

The objectives of Task 1 were as follows.

1. Gather, inventory, and review existing conditions information to define the physical constraints surrounding New York Penn Station (PSNY) that could limit achievable near-term improvements and define the space into which a potential project might fit.
2. Create a database of plans, feasibility reports and other reference documents gathered that will be useful to NJ TRANSIT for other projects and for future efforts.
3. Create a database query tool and associated database manual for efficient analysis and retrieval of the information assembled by LTK & Arup.

Given the volume of information potentially available on projects planned or constructed in and around Penn Station over the last 100 years, the data collection effort was necessarily limited. The data collection and review effort was focused on information that is likely to define the space constraints within which the Study alternatives must fit and which could significantly influence the feasibility of these alternatives. The existing relevant past plans and projects were reviewed, with key constraints relevant to this effort highlighted.

2.1 Review of Existing Documentation

The Study Team gathered, organized, and reviewed relevant existing documents available in Arup, LTK, and Matrix New World offices; the documentation provided by NJ TRANSIT, Amtrak and their consultant team (STV and WSP); NYCT archive information; NYC Department of Buildings (DOB), and other documentation obtained specifically for this study. The following is a partial list of the main drawings and documents gathered and incorporated into the PCIP Study database.

Relevant projects abandoned or not completed:

- 30% Preliminary Design Engineering Drawings for the Trans-Hudson Express (THE) Project.
- Advanced Conceptual Engineering (ACE) Report developed for the Draft Environmental Impact Statement of the Access to the Region's Core (ARC) Project.
- Engineering Report for the Environmental Impact Statement of the Access to the Region's Core (ARC) Project.
- 30% Preliminary Design Engineering Drawings and Reports developed for the Penn Station New York Capacity Enhancement Project (PSCE) which considered extending Platforms 1 & 2 among other new track improvements.

Relevant projects completed or currently underway:

- 30% Draft Preliminary Design Engineering Drawings and Reports developed for the Hudson River Tunnel Project (HRT).
- 10% Design Report developed for the PSNY Central Concourse Project.
- Final Report and as-built Survey developed for the Penn Station New York Visioning Study.
- Construction Engineering Drawings developed for the No. 7 Flushing Subway Line Extension Project.

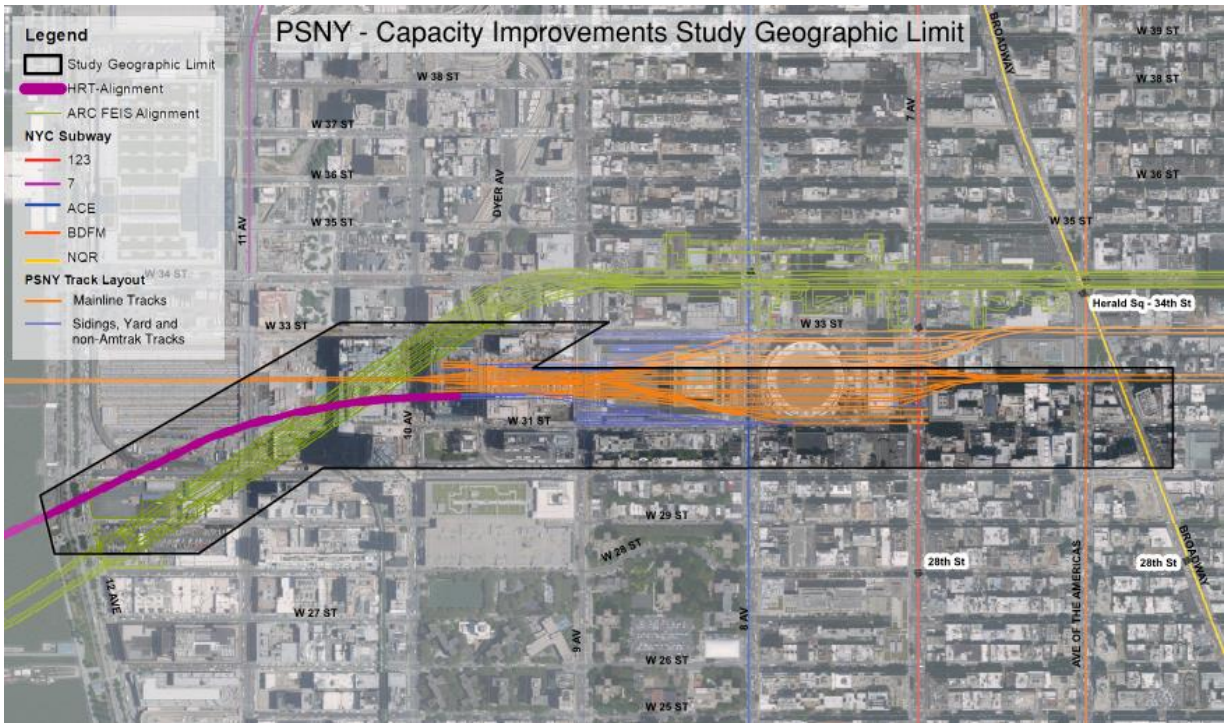
Historic and as-built documentation:

- Copies of historic PSNY drawings including approximately 330 sheets obtained from Amtrak as-built archives.
- Archival drawings of the Sixth Avenue, Seventh Avenue, Eighth Avenue, and Broadway subway lines as obtained from the MTA-NYCT microfilm archives.
- As-built survey for the Redevelopment of the James A. Farley Building prepared by Post, Buckley, Schuh & Jernigan, Inc.
- As-built survey developed based on 2005 aerial photogrammetry for THE Project by Robinson Aerial Surveys.
- As-built survey and existing base mapping of the infrastructure within PSNY developed for several projects (1998-2013), including, but not limited to, the HRT Project, the ARC Project, the ACE Project, the Vision Study and the PSNY Central Concourse project.
- Rock contours obtained from the geotechnical reports of various projects within the geographic limit of this Study and developed by Arup Geotechnical group.

2.2 Project Geographic Limits

The geographic limits of this study and the existing track layout at Penn Station is shown on Figure 1. For reference, this figure also shows the existing NYCT subway lines in the vicinity of the study area, the currently proposed HRT track approach to PSNY, and the track alignment for the 34th Street Station that was planned to be built under ARC. The development of the Task 2 base map focused on the area within these geographic limits.

The Project geographic limits were determined in coordination with NJ TRANSIT based on the scope and the goals and objectives of the PCIP Study. These limits include the south section of PSNY, namely the platforms serviced by NJ TRANSIT and the area along 31st Street between 6th Avenue and 9th Avenue. The proposed location for the new HRT tunnel portal as well as the location of the original ARC portal are also within the geographic limits of the Study.



Source: Developed for the PCIP Study based on data and documentation compiled.

Figure 1: PSNY Capacity Improvements Project (PCIP) - Geographic limits.

2.3 Highlight of Key Constraints

Alternatives for PSNY capacity improvements under the PCIP Study were considered generally between 30th Street and 33rd Street and between 6th Avenue and 10th Avenue as shown in Figure 1. This part of Manhattan has a complex network of transportation lines, a complex mixture of new and old buildings, and has undergone major redevelopment in recent years. Therefore, it was essential that the space constraints imposed by the existing and planned physical built environment were properly considered during the proposal and evaluation of alternatives.

These constraints and the envelope into which a potential PCIP Study alternative might fit were best defined by the 3D base map model and the cross sections developed under Task 2. This chapter provides a brief summary of the existing main infrastructure identified within the geographic limit of the study and considered in the development of alternatives.

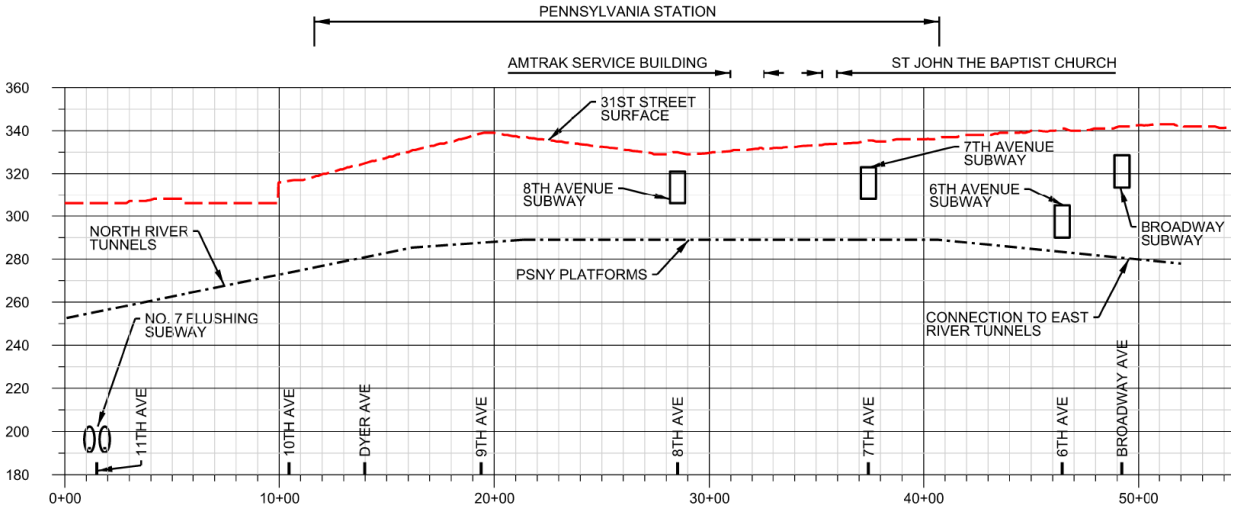
The existing PSNY platforms and tracks used by NJ TRANSIT are located on the third underground level of the station at an approximate elevation (Pennsylvania Railroad Datum) of 288.99ft. This elevation varies slightly across tracks and platforms and is provided as a reference only for relative comparison of elevations with the constraints described below. All elevations provided below are in feet and are referenced to the Pennsylvania Railroad Tunnels Datum, which is the vertical datum used for the Hudson River Tunnel (HRT) Project; its use facilitated coordination with related projects and key stakeholders. This vertical datum was chosen since one primary goal of the PCIP Study is to identify improvements that can take advantage of the new trans-Hudson capacity once the HRT project is complete. As such, it was selected to avoid any confusion when developing alternatives that could be integrated with the HRT project.

NYCT lines that are potential design constraints include:

- The 6th Avenue Subway line (Route 101, partial sections: 8 and 9) runs nearly in the north-south direction below 6th Avenue. The base of the tunnel is located 45ft to 50ft below the street surface. At the intersection with 31st Street, the elevation of the base of the rail is 294.73ft and the base of the structural support is approximately 2ft to 3ft below it. (That's 291' compared to PSNY's 289').
- The 7th Avenue Subway line (Route 4 & 38, partial sections: 5 and 6) runs nearly in the north-south direction below 7th Avenue. The base of the tunnel is located 20ft to 25ft below the street surface. At the intersection with 31st Street, the elevation of the base of the rail is 312.25ft and the base of the structural support is approximately 2ft to 3ft below it. (That's 309' compared to PSNY's 289').
- The 8th Avenue Subway line (Route 102, partial section: 3) runs nearly in the north-south direction below 8th Avenue. The base of the tunnel is located 25ft to 30ft below the street surface. At the intersection with 31st Street, the elevation of the base of the rail is 310.90ft and the base of the structural support is approximately 2ft to 3ft below it. (That's 308' compared to PSNY's 289').
- The Broadway Subway line (Route 4 & 36, partial section: 2) runs nearly in the north-south direction below Broadway. The base of the tunnel is located 25ft to 30ft below the street surface. At the intersection with 31st Street, the elevation of the base of the rail is 317.58ft and the base of the structural support is approximately 2ft to 3ft below it. (That's 315' compared to PSNY's 289'). The elevation of Broadway Subway line is higher than the 6th Avenue Subway; therefore, this line is not expected to impose major constraints in the development of alternatives.
- The No. 7 Flushing Subway line (Westward extension of Route 104 section 1) runs nearly in the north-south direction below 11th Avenue between a point just south of 25th Street and

38th Street. The base of the tunnel is located 125ft to 130ft below the street surface. The elevation of the base of the rail is 191.35ft at the intersection with 30st Street. The elevation of these tunnels is approximately 100ft below the existing tracks at PSNY and therefore it is reasonable to assume that it would not impose any constraints on this study.

Figure 2 below graphically shows the approximate spatial relationship between these potential design constraints.



** All elevations shown are approximate.*

*** North River Tunnels, PSNY Platforms and the connection to the East River Tunnels are not within the limits of 31st street and are shown for reference only.*

Source: Developed for the PCIP Study based on data and documentation compiled.

Figure 2: 31st Street Profile - Relevant NYCT Subway Lines.

Major utilities that are potential design constraints include:

- The NYC Water Tunnel No. 1 runs underneath the east side of 6th Avenue until 33rd Street and then it continues south underneath the east side of Broadway. The tunnel was completed in 1917 and is expected to undergo comprehensive repairs upon completion of Tunnel No. 3. The invert elevation of the 13ft diameter tunnel is 140 ft.
- The section of the NYC Water Tunnel No. 3 within the study area is located roughly 500ft below the surface level and therefore it is reasonable to assume that it would not impose any constraints on this study.

Buildings that are potential design constraints include:

- The 11 Penn Plaza office building is located on the northeast corner of 31st Street and 7th Avenue and constitutes one of the major constraints for the eastward extension of Tracks 1 through 4. The building, which was constructed in 1924 and has 26 floors, was designed in compliance with an easement which provided space in the second sub-basement for future extension of the PSNY tracks. The building has three basement levels and the elevation of the top of the 2nd sub-basement floor is 289.15ft. The building is currently owned by Vornado Realty Trust. There is a transformer room, within the mentioned railroad

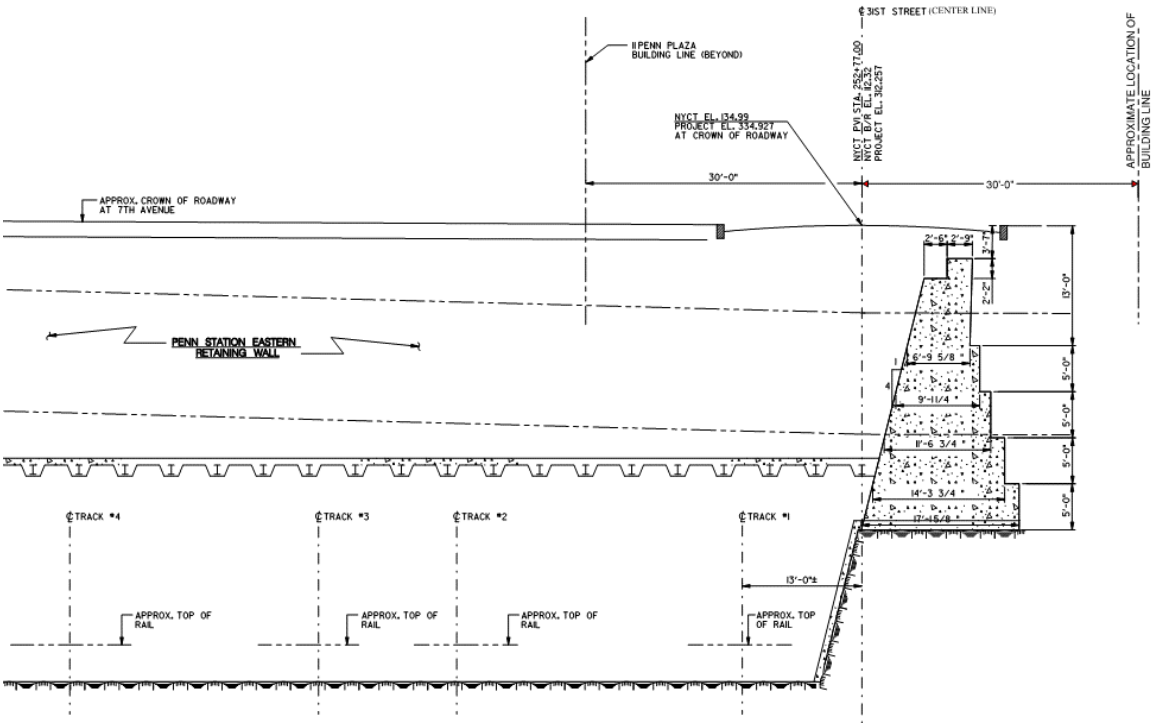
easement area, where Con Edison electrical power is stepped up and distributed to the building. The extension of platforms and tracks proposed in the PSCE Study was designed to minimize any impacts on this room, accordingly, the extension proposed for Tracks 3 and 4 stopped under the sidewalk/building vault of 11 Penn Plaza in the PSCE Study, avoiding the relocation of equipment in the subject room. The mentioned railroad easement could provide for pedestrian access point between PSNY and points east of 7th Avenue, and was used for a proposed connection to the 32nd Street entrance of the 7th Avenue subway in the PSCE design.

- Information for the relevant buildings located directly south of PSNY and 31st Street has been summarized in Figure 6 at the end of this section. This information was obtained from the NYC Department of Buildings and the NYC Open Data Portal.

Spatial, structural and geotechnical potential design constraints include:

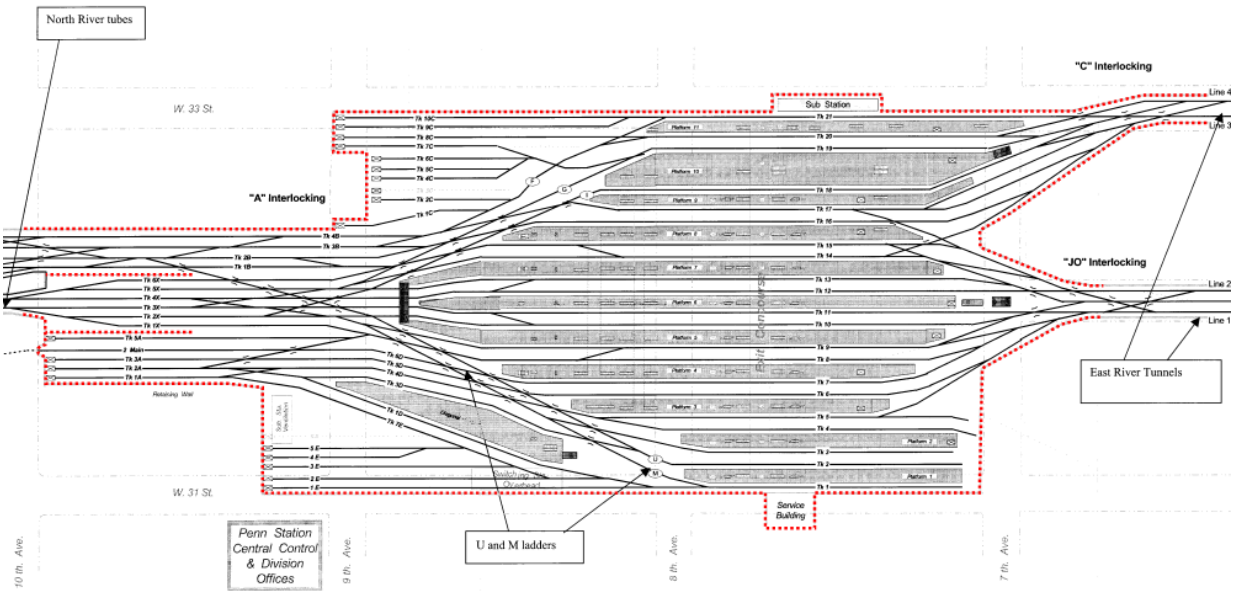
- Track 1 in PSNY is located underneath the north side of 31st Street and its centerline is approximately 13ft from the centerline of the street and 43ft from the building line on the south side of the street. Figure 3 shows a north-south cross section of the existing conditions below 31st Street developed as part of the Penn Station Capacity Enhancement (PSCE) Project. Based on the information reviewed, the available space underneath the 31st Street right of way for the potential construction of new tracks is severely limited. It is estimated that there is less than 12ft between the PSNY south retaining wall and the existing building line south of 31st Street. Therefore, it is anticipated that construction of new tracks under 31st Street will require significant modifications to the retaining wall and would likely impact the buildings on Block 780. In addition, the existing basement and foundation configurations of the buildings along 31st Street between 7th Avenue and 10th Avenue will significantly influence the spatial feasibility of adding tracks and platforms south of Track 1.
- The existing PSNY retaining wall surrounds the station including the west PSNY access tracks, Yard "A", "C", D" and "E and PSNY Tracks 1-21. The retaining wall is discontinuous in specific locations to provide train access to the station for the Empire Line, the North River Tunnels, and the LIRR West Side Yard on the west and for the "C" and "JO" interlockings that lead to the East River Tunnels on the east. The width and depth of the retaining wall varies based on the existing environment, building configuration, and the loads imposed by the structural elements (girders and beams) that the retaining wall supports. For reference, Figure 3 includes a section of the retaining wall in the area of interest (below 31st Street). As shown, the width of the existing retaining wall that surrounds the south side of PSNY increases with wall depth to approximately 22ft at the top of rail elevation. The electrical substation on the north side of PSNY and the former Amtrak Electric Generating Station on the south side are also within the retaining wall as can be seen in Figure 4, which shows the general extent of the retaining wall in relation to the PSNY track level.
- Water infiltration is another important constraint that needs to be considered in the design of any alternative selected for advancement. The existing waterproofing of the station will

have to be protected or replaced as necessary based on the final configuration of the potential alternatives to mitigate any future water intrusion.



Source: PSCE 30% Preliminary Engineering Design Drawings. DWG No. ST-119.

Figure 3: PSNY North-South Cross Section of the Existing Conditions.



Source: PSNY Track Level Plan developed by Amtrak Transportation Planning. Last Revised 2001.

Figure 4: PSNY Schematic Track Level Plan Showing Retaining Wall Extent.

2.4 Relevant Projects

Given the extensive number of PSNY improvements planned over the past several decades, and the number of planning projects generally focused on West Midtown, it would be difficult to document the focus and findings of each within the budget and schedule constraints of this Study. Therefore, this work focuses on those projects most relevant to this study in terms of those most aligned with the same goals and objectives, those that could support the improvements proposed, or those that could place new constraints on alternatives likely to be proposed. The relevant projects summarized here were organized into projects abandoned/not completed, projects completed and projects underway.

Relevant projects abandoned or not completed include:

- Access to the Region's Core

The Access to the Region's Core (ARC) Project, also known as Trans Hudson Express Tunnel Project (THE Tunnel), would have built new trackage, a new rail yard, and new tunnels under the Hudson River to increase trans-Hudson capacity from an existing of 26 trains per hour (TPH) to a 2030 Build capacity of 48 TPH. Additional capacity would have been provided by constructing two new tracks along the south side of the existing Northeast Corridor (NEC) from Frank R. Lautenberg Station through two tunnels under the Palisades and the Hudson River, and connecting them to a new station, known as New York Penn Station Expansion (NYPSE), that would have been constructed under West 34th Street between 8th Avenue and 6th Avenue in midtown Manhattan. Construction began in mid-2009, however the project was cancelled in October 2010 due to the possibility of cost overruns and the lack of funding.

As part of the ARC Draft Environmental Impact Statement (DEIS) efforts, several near-term alternatives that would improve capacity and pedestrian access in PSNY were also analyzed and considered: 31st Street Linear Yard, "C" Yard Extension, 12th Avenue Yard, Expanded "E" Yard Capacity, West End Concourse Extension, Central Concourse Extension, modifications to the "U" and "M" Ladders, and Extensions of PSNY Tracks 1-4 and Platforms 1 and 2 both to the east and west.

- Advanced Conceptual Engineering Report (ACE Report)

The ACE Report was developed by Transit Link Consultants (a joint venture of PB -now WSP- and SYSTRA) as part of the ARC DEIS and examined the feasibility, functionality, costs and operational impact of several alternatives to improve NJ TRANSIT capacity in PSNY. The ACE Report included the following potential alternatives:

- Task 1: West End Concourse extension with connection to existing Platforms 1 and 2 through either existing PSNY passageways or new 31st Street passageway.
- Task 2: Westward extension of Platforms 1 and 2 with new ladder track south of "M" Ladder.
- Task 3: West End Concourse extension with direct connection to extended Platforms 1 and 2.
- Task 4: Eastward extension of Platforms 1 and 2.

- Penn Station Capacity Enhancement

The Penn Station Capacity Enhancement (PSCE) Project was based on the previous work performed for the ACE Report in 2005 as part of the ARC DEIS. The main objectives of the PSCE project were to further develop a more advanced design building upon the ACE study to extend PSNY Platforms 1 and 2 and Tracks 1 to 4 to accommodate a train consist of a locomotive plus ten coaches, and to improve the passenger connections to the west end of PSNY Level "A". These improvements aimed to increase the near-term capacity for NJ TRANSIT in PSNY. The 30% Preliminary Engineering Design was completed in 2007; however, the design did not progress any further. This project was divided into three independent tasks:

- Task 2: Eastward extensions of Platforms 1 and 2.
- Task 3: Westward extensions of Platforms 1 and 2 and "U" & "M" Ladders reconfiguration.
- Task 4: West End Concourse extension and stairways to Platforms 1 and 2.

Relevant projects completed include:

- The 1986-89 Penn Station New York Access Project

The 1986-89 Penn Station New York Access Project undertaken by LS Transit Systems (now SYSTRA) for NJ TRANSIT included a broad range of alternative rail services and infrastructure improvements to increase capacity into PSNY via the then-underused North River Tunnels. One alternative, the “X” Tracks, and, specifically, the capacity benefits of expanding the 30 MPH Track 3X movement to Track 1X, represent a promising element of that early study that is considered in this PCIP Study. Provisions were included in early High-Density Interlocking System (HDIS) signaling for such a 30 MPH route but were later abandoned due to concerns about NORAC operating rules conformance and the non-standard turnout No. 12 (Amtrak standard is No. 15) required.

This project also studied the feasibility of westward and eastward extensions of Penn Station Tracks 1 to 4. Eastward extension is complex due to the potential conflicts with the NYCT 7th Avenue Subway and structural considerations related to the existing buildings along 7th Avenue. Alternatives that consider a westward extension are challenged by the need to maintain tie-ins to the “U” and “M” Ladders, platform-vehicle gap issues, imports to existing E-yard, column conflicts and the non-standard geometry of the existing special trackwork.

- 2010-2015 New York Penn Station Operations Study

The 2010-2015 New York Penn Station Operations Study, funded by Amtrak, NJ TRANSIT, LIRR and Metro-North, quantified the existing North River Tunnel capacity at 26 TPH. The June 2015 final report notes that the scheduled volume of 25 TPH spans almost two peak hours in the morning, a much more extended peak service delivery than corresponding East River Tunnel operations. The study focused on operating changes at the station to increase overall throughput of the four rail carriers rather than infrastructure improvements.

- Penn Station Visioning

The Penn Station Visioning study provided a series of phased customer focused improvements that aimed to transform the station into a world-class facility; a more unified, modern and functional Penn Station. The main objective of this project which was completed in 2014 was to propose, analyze and recommend a feasible plan to provide an enhanced customer experience at PSNY by increasing station accessibility and natural daylight access, improving wayfinding, implementing a unified station signage and performing exterior improvements in the vicinity of the station.

Relevant projects currently underway include:

- Hudson River Tunnel Project

The Hudson River Tunnel Project (HRT) includes the design and construction of two new tracks extending from the Northeast Corridor (NEC) in Secaucus, continuing in new tunnels beneath the Palisades and the Hoboken waterfront area, and beneath the Hudson River to connect to the existing approach tracks that lead into PSNY. In addition, this project will rehabilitate and modernize the existing North River Tunnels (NRT) which incurred serious damage during Super Storm Sandy. The construction of the new rail tunnels would be phased so that the NEC service can remain active and service would be transferred to the new tunnel while the existing NRT is rehabilitated. The HRT project, which is part of the larger long-term Gateway Program, is a follow-on project to ARC, although it has some significant differences. While the HRT project would result in transportation benefits, including increased reliability through improved resiliency and redundant operational capability, it would not, by itself, increase rail capacity which would remain constrained at PSNY. The HRT project would not enable Amtrak or NJ TRANSIT to increase peak-hour service without the completion of additional capacity improvements at PSNY.

The new tunnel would follow the same route in New Jersey as the previous ARC project and would utilize and modify the existing PSNY “A” Yard tracks as well as extend the PSNY “I” Ladder to provide an efficient connection to the different tracks and platforms and maximize flexibility of operations while minimizing impact to existing service during construction. Due to these modifications, “E” Yard train layover capacity for passenger equipment and associated utilization would likely be eliminated once the HRT project is completed.

- Gateway Program

The Gateway Program is the planned phased renovation and expansion to eventually create four mainline tracks of the NEC between Newark and New York City. The comprehensive program would include replacing the existing Sawtooth Bridges; completing the Secaucus Junction and Bergen Loop Project and the Right-of-Way Preservation Project (Hudson Yards Concrete Casing), building additional mainline tracks, new rail bridges in the New Jersey Meadowlands (Portal Bridge Project), a new NJ TRANSIT Rail Yard and new tunnels under Bergen Hill and the Hudson River (HRT); and adding a potential terminal annex to PSNY (Penn Station Expansion Project) south of 31st Street.

The existing NRT operates at a maximum capacity for nearly two hours every weekday morning and evening. The Gateway Program which was unveiled in 2011, after the cancellation of the ARC project, as one of the critical steps necessary to bring next-generation high-speed rail to the Northeast Corridor, would increase train capacity across the Hudson River by building two additional mainline tracks in between Newark and PSNY. The capacity gains achievable with the new Hudson River Tunnels has been estimated to be between 18 and 24 additional trains per hour per direction. The proposed improvements would allow for additional growth in commuter and inter-city high-speed rail services. The right-of-way would parallel the existing corridor between Newark Penn Station and PSNY in Midtown Manhattan.

- Moynihan Train Hall

The Moynihan Train Hall project would expand PSNY passenger facilities across 8th Avenue into the historic James A. Farley Post Office Building, part of a mixed-use redevelopment of the entire Block 755 located between 8th and 9th Avenues. The Moynihan Train Hall would offer enhanced passenger facilities for Amtrak's NEC and long-distance travelers, would relieve existing station crowding, would improve passenger comfort and security, and would increase accessibility for passengers with disabilities. The main operating benefits associated with this project are the addition of vertical circulation elements that would improve access and egress from existing platforms and improved crew staging and crew access to platforms. No track related improvements are proposed.

In 2010, the fully designed elements of the plan were broken off into two phases:

- Phase 1 would create the "West End Concourse" to provide additional connectivity between existing PSNY Platforms 3 through 11. Moreover, this phase would add two street level entrances to provide direct access to this new concourse through the Farley Building on 8th Avenue. Phase 1 has been completed and the extended West End Concourse opened in the eastern part of the former post office in June 2017.
- Phase 2 would build a new train hall in the fully renovated Farley Building. The Farley Post Office would be divided so that there would be some space for a shared Amtrak/LIRR train hall and a retail area, as well as space for the post office. Preliminary construction work for Phase 2 started in August 2017.

The LIRR and Amtrak passenger concourse access will provide improved connections to the new Moynihan Train Hall once the project is fully completed (expected to occur by 2021). NJ TRANSIT, however, will be limited to using its existing passenger concourses given that the platforms predominantly used by NJ TRANSIT are further east. The location of the existing "U" & "M" ladders that serve the NJ TRANSIT prevents expansion of the platforms westward to below the Moynihan Train Hall.

- Hudson Yards

Hudson Yards refers to the area spanning between 30th Street and 43rd Street and 7th Avenue and 12th Avenue in Midtown Manhattan. This area, which was generally isolated from the subway system, had few public amenities and was primarily characterized by underutilized

land, is the focus of a large-scale redevelopment program planned, funded and constructed under a set of agreements between the New York Metropolitan Transportation Authority (MTA), New York City (NYC) and the State of New York (NY). The comprehensive program aims to realize the development potential of Manhattan's Far West Side and its four main objectives are to 1) extend subway service to the area, 2) establish a new open space network, 3) modify the zoning map to support appropriate densities and uses, and 4) create a convention corridor.

As part of this program, the NYC Council approved a comprehensive rezoning of Hudson Yards in 2005 (Hudson Yards Follow-up Text Amendments were approved in 2009) that, among other modifications, enable developers of commercial or residential projects in the Hudson Yards area to receive a zoning bonus that would allow their projects to exceed the "base" maximum floor area ratio (FAR) established. To qualify for this zoning bonus, developers would have to make a payment to the District Improvement Fund, which was stablished to help finance infrastructure improvements in the Hudson Yard area, as specified in the Zoning Resolution. The two main developments relevant to this Study are:

- Hudson Yards

Hudson Yards is a 26-acre, 16-building mixed-used redevelopment project by Related Companies and Oxford Properties. The project is building over the existing LIRR West Side Yard located between 30th Street and 33rd Street and 10th Avenue and 12th Avenue in Midtown Manhattan. The site will include more than 18 million square feet of commercial and residential space and, upon completion, all but three of the approximately 16 planned structures will sit on a platform placed over the subject yard. Hudson Yards construction started in 2012 and is expected to be completed by 2024.

In response to this large-scale redevelopment over the West Side Yard, Amtrak planned the Right-of-Way Preservation Project which would build a concrete tunnel box along the south side of West Side Yard to maintain a rail right-of-way beneath the Hudson Yards overbuild project. The HRT alignment would make use of the Right-of-Way Preservation Project, which is currently under construction, to connect to the southwestern end of PSNY approach tracks.

- Manhattan West

Manhattan West is an eight-acre, six-building mixed-use development project by Brookfield Property Partners. The 5,400,000-square-foot mixed-use development is located between 9th Avenue and 10th Avenue and 31st Street and 33rd Street. The project consists of two large office towers also known as Brookfield Towers (One Manhattan West and Two Manhattan West) and two smaller residential towers, as well as a public park. The towers are being built on a platform over PSNY storage tracks along 9th Avenue. The platform was completed in November 2014. The completion of One Manhattan West is expected by December 2019. The second office tower will be constructed when an anchor tenant is secured.

During the Environmental Impact Statement of the ARC Project, it was identified that the Manhattan West development would impact ARC's proposed connection to Penn Station. Brookfield Properties was made aware of these issues and several alternatives to minimize

these impacts were studied. The PCIP Study evaluated if the original ARC route to 34th Street is still feasible given this and the Hudson Yards development. Results of that evaluation are provided in Section 5.1.9.

2.5 PSNY Passenger Movement and Access

Passenger movement within PSNY is constrained by the station's current configuration and limited number of access points. Penn Station's multi-leveled layout, unaligned floorplates and numerous bottlenecks and pinch points make traveling through the station disorienting, particularly for visitors and tourists. High passenger volumes and the constrained layout of the station combined with short boarding and alighting times due to frequency of train operations mean Penn Station is prone to overcrowding and lengthy queueing. Low ceiling heights throughout the station limit visibility and intuitive wayfinding.

2.5.1 Passenger Forecasts and Pedestrian Movements

Penn Station, New York (PSNY) has experienced a significant increase in daily passenger loads in the last fifty years (from 200,000 to over 600,000 daily users) which has exposed the station's functional limitations and constrain the station's capacity, operating efficiency and passenger comfort and convenience. Penn Station functions as both New York City's primary commuter station, and as the principal hub of the Northeast Corridor (NEC), the busiest rail corridor in the country. Approximately 60% of the NEC's trips either begin or end at Penn Station. As of 2017, the latest year for which ridership values have been made public, there were approximately 233,000 LIRR, 29,000 Amtrak, and 187,000 NJ TRANSIT daily passenger trips to and from Penn Station. With the addition of the adjacent NYCT subway stations, it is estimated that over 600,000 people passed through Penn Station daily during 2017.

Ridership at PSNY is expected to grow considerably in the coming decades. While the opening of Moynihan Train Hall and the completion of the East Side Access project are expected to temporarily reduce the number of passengers moving through Penn Station, the estimated ridership increase of Amtrak, LIRR and NJ TRANSIT and the eventual completion of both the Gateway Program and the Penn Station Access Project would require that an additional 150,000 commuters are accommodated at PSNY by 2040 according to a 2018 projection by the Regional Plan Association. Furthermore a pedestrian circulation analysis completed for the Moynihan Station Phase 1 project in 2010 estimated that ridership during the AM peak hour would increase 44% from 67,000 in 2008 to over 96,000 LIRR, NJ TRANSIT, and Amtrak passengers by 2035, which was considered the "horizon year" as it represents when the station is estimated to operate at or close to the practical capacity of the tunnels, interlocking and platform tracks. The PM peak saw an even sharper increase, as total ridership in the station was projected to increase from 55,430 to 93,300 during the PM peak hour from 2008 to the horizon year, an increase of 68%.

2.5.2 Access and Circulation

Due to the commuting patterns of LIRR and NJ TRANSIT passengers, the station is more congested during the PM peak than during the AM peak. This is due to commuters needing to previously queue for their trains during the PM peak, rather than being able to directly exit the station when their train arrives during the AM peak.

Specific access and circulation patterns for each level—including challenges, bottlenecks, and areas prone to crowding—are as follows:

2.5.2.1 Street Level

Penn Station is accessed at street level from six separate, dissimilar station entrances: 1) the station's primary entrance at 33rd Street and 7th Avenue, 2) the 34th Street and 7th Avenue LIRR street-level entrance, within the 1 Penn Plaza block, 3) the NJ TRANSIT entrance at 32nd and 7th Avenue, 4) the 8th Avenue and 33rd Street entrance, 5) the 31st Street and 8th Avenue entrance, and 6) the pedestrian entrance at former taxiway which runs north/south within the Madison Square Garden/2 Penn Plaza superblock. Two additional entrances are under construction at 33rd and 31st streets on the west side of 8th Avenue as part of the Moynihan Train Hall project. Several of these access points connect at street level to public plazas that are controlled by Madison Square Garden and Vornado, the owners respectively of One and Two Penn Plaza.

The station lacks a strong visual presence or identity in the neighborhood, and signage indicating station entrances compete visually with signs for Madison Square Garden and Two Penn Plaza. This makes navigating to the station difficult, especially for visitors and tourists.

2.5.2.2 Main Level ("Level B")

Located immediately below the street, the Main Level includes connections to the station's main entrance at 7th Avenue and 32nd Street. The level includes a large Amtrak waiting area in the western portion of station, as well as extensive space dedicated to retail, back-of-house operations for Amtrak and NJ TRANSIT, and mechanical uses.

NJ TRANSIT passengers mostly utilize this level including the passenger operations facility on the southeast corner of the station, near 7th Avenue and the entrance at 7th Avenue and 31st Street. Located near the ticket windows parallel to 7th Avenue, the NJ TRANSIT East End Concourse area is prone to overcrowding, as passengers gather here to stand as close as possible to track entrances. The split-level nature of the NJ TRANSIT East End Concourse further complicates circulation. Another important pinch point and bottleneck on the Main Level is the primary entrance at 7th Avenue and 32nd Street, which has stairs and one escalator in each direction and experiences high pedestrian volumes during the peak hours.

2.5.2.3 Lower Level ("Level A")

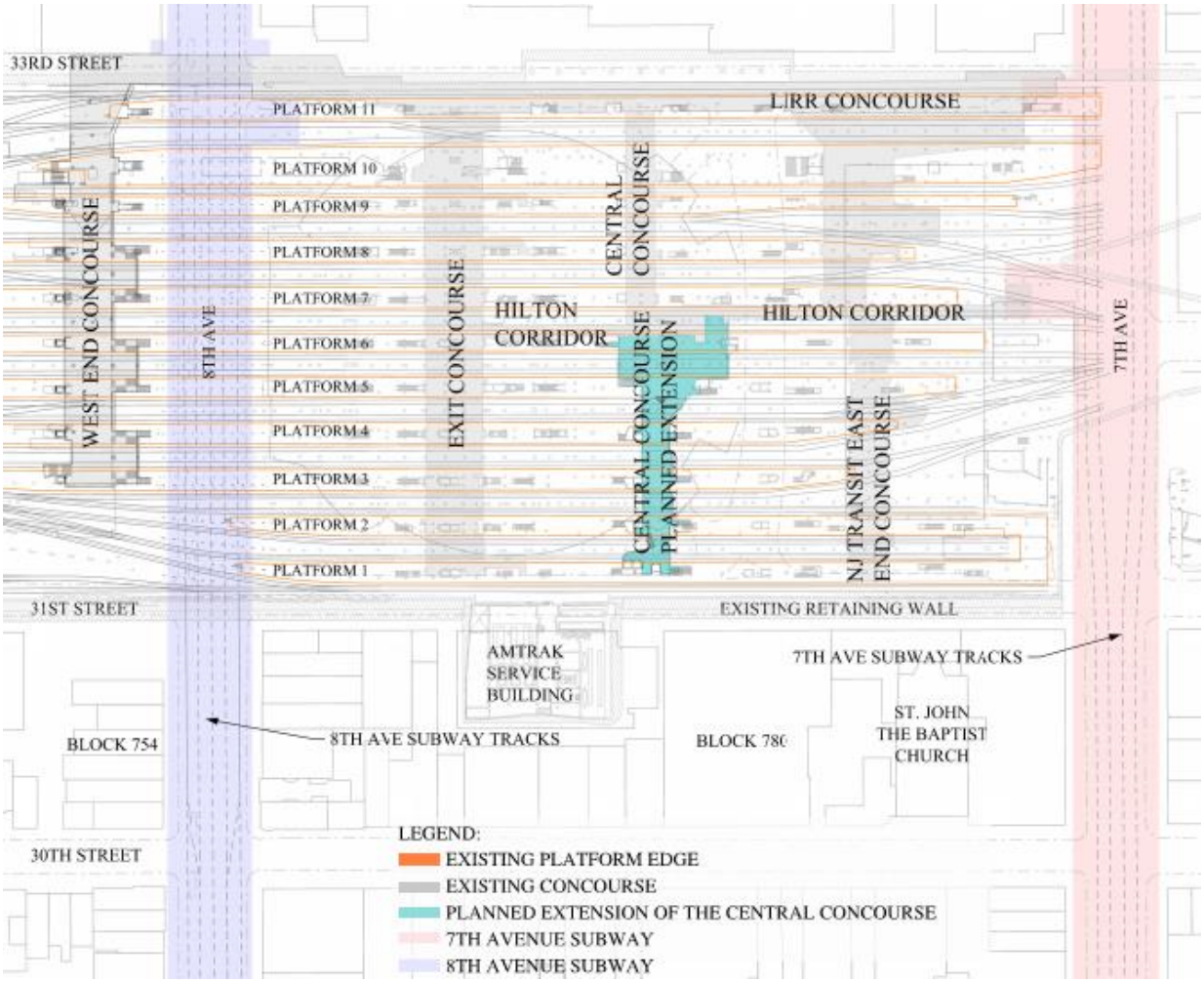
The Lower Level provides direct connections to the NYCT 7th Avenue and 8th Avenue Subway stations and includes ticketing and waiting areas for NJ TRANSIT and LIRR. The Penn Visioning Study identified the Lower Level as the most congested in the station.

On the Lower Level, the Exit Concourse on the west side of the station has limited room for waiting, and the Central Concourse does not currently extend over NJ TRANSIT platforms. This leads to a majority of NJ TRANSIT passengers having to travel through the mezzanine area of the NJ TRANSIT East End Concourse. Similar to the rest of the station, the mezzanine area performs far better during the AM peak than during the PM peak, as passengers can directly exit the station in the morning but are queuing before train departures in the evening as they wait for platform assignments.

The Hilton Passageway divides the LIRR (north side) and NJ TRANSIT (south side) sections of the station. The narrowness and irregular shape of the passageway limits its usefulness as a primary east-west connection. Outside of the geographic limits of this project, the LIRR Concourse, located below 33rd Street, is the station's primary east/west passage, providing the main connection between the station and the adjacent 34th Street /7th Avenue LIRR entrance and 8th Avenue Subway entrance. This passageway is also prone to high levels of congestion during peak hours. Figure 5 shows a general overview plan of the existing concourses at PSNY Level A. It is important to note that while the planned extension of the Central Concourse is not completed, this project was considered part of the baseline of the PCIP Study and therefore it is included for reference.

2.5.2.4 Track/Platform Level

Penn Station's platforms experience extensive crowding, especially when peak period trains discharge and vertical circulation is congested. Extensive crowding also occurs during simultaneous boarding and discharge events occurring on two tracks accessing a single platform. Boarding passengers must queue on other levels first at monitors while they wait for their track number to be called. Once platform assignments are announced there is a rush of passengers making their way through the crowds to get to their train. Vertical circulation cores take up valuable platform space and restrict passage widths; the mixing of disembarking passengers and boarding passengers can lead to delays in loading trains and late departures, which can in turn increase congestion.



Source: Developed for the PCIP Study based on data and documentation compiled.

Figure 5: Overview Plan of the Concourses at PSNY.

2.5.3 Signage and Wayfinding

Penn Station lacks a unified visual presence. At street level, station entrances employ inconsistent names (Penn Station vs. Pennsylvania Station), or do not identify all the railroads operating within the station. Visual clutter also makes it challenging to distinguish station signage from signage for Madison Square Garden, nearby office developments, retail uses, and advertisements.

Within the station, intuitive wayfinding is restricted by:

- **Signage Placement** – Signs are often not placed in the optimal locations. There is a lack of signs placed perpendicular to desired pedestrian travel paths, and directional signage is often blocked by low-hanging structures or crowds of pedestrians.
- **Competing sign systems** – Signs lack uniformity throughout the station. The different railroad operators use different colors, typefaces, heights, sizes and graphic symbols.

Moreover, the colors used do not necessarily relate to or are associated with each railroad. In addition to the railroad signs, there are many advertisement signs and other signs associated with various retail stores which significantly contributes to the existing visual clutter. NJ TRANSIT is currently working with Amtrak and LIRR to advance a unified signage plan.

Due to the station's long history of reconstruction and renovation, Penn Station's inconsistent architectural treatments add to the challenge of intuitive wayfinding. Materials vary throughout the station. The design of boarding gates, for example, are dictated by each railroad.

In the past, station maps within Penn Station were specific to a railroad. However, NJ TRANSIT recently worked with Amtrak and LIRR to develop and install a unified station map, which has now been installed throughout the station.

2.5.4 Passenger Circulation Recommendations from Previous and Current Planning Efforts

The previous planning studies reviewed as part of the PCIP work advanced numerous ideas for improving passenger circulation, access and wayfinding within the station. Table 1 summarizes major proposed improvements that impact the entirety of the station, or that are relevant to the efforts of this Study. Improvements proposed exclusively for Amtrak and LIRR are not included.

Relevant Passenger Circulation and Access Improvement	**Timeframe***	**Planning Effort**
Add additional dynamic signage throughout Lower and Main Levels. Investigate options for adding dynamic signage at street levels, including 8th Avenue entrances and within the vestibule of the 7th Avenue and 31st Street entrance.	Near Term	Penn Station Visioning Study
Employ new alphabetical naming convention for boarding areas to aid in passenger navigation.	Near Term	Penn Station Visioning Study
Create a unified graphic wayfinding program for static signage throughout the station by employing consistent fonts, colors, iconography and materials.	Near Term	Penn Station Visioning Study
Add new wayfinding signage, especially signs located perpendicular to pedestrian travel paths.	Near Term	Penn Station Visioning Study
Expand Central Concourse. Add new stairs and elevators to provide connections from Track / Platform Level to the Main and Street Levels. Add new enclosed head house and entrance midblock on 31st Street.	Medium Term	PSNY Central Concourse Project
Create new 31st Street Concourse to provide new east/west circulation option.	Medium Term	Penn Station Visioning Study
Modify Main Level Amtrak Waiting Area/Rotunda Area. Renovate retail and improve architectural features.	Medium Term	PSNY Central Concourse Project
Reconfigure NJ TRANSIT East End Concourse to include additional queueing and waiting areas.	Long Term	Penn Station Visioning Study

Relevant Passenger Circulation and Access Improvement	Timeframe*	Planning Effort
Expand and realign the Hilton Passageway to improve east/west connections and better align the station with the Manhattan street grid.	Long Term	Penn Station Visioning Study
Create openings between Track and Lower Levels to provide visual connections and aid in intuitive wayfinding.	Long Term	Penn Station Visioning Study
Add new connections to the West End Concourse by connecting the West End Concourse to Platform 3 under 8th Avenue Subway (option 1) or connecting to Platforms 1 and 2 under 8th Avenue Subway via 31st Street underpass (option 2).	NA**	Penn Station Capacity Enhancement Project
Provide passageway to 32nd Street subway entrance by extending platforms 1 and 2. Provide pedestrian connection from NJ TRANSIT East End Concourse to 32nd Street entrance of 7th Avenue Subway station.	NA**	Penn Station Capacity Enhancement Project

** Timeframe – as identified in the Penn Station Visioning Study. This study identified "Future", "Near Term" and "Interim" projects. To aid in the inclusion of projects from other planning efforts, "Interim" and "Future" projects were redesignated as "Medium Term" and "Long Term" respectively. The Penn Station Visioning Study Final Report was published in 2016 and the timeframe indicated may no longer reflect the current vision.*

*** As noted earlier on the report, The Penn Station Capacity Enhancement Project was cancelled and therefore a timeframe is not provided.*

Source: Developed for the PCIP Study based on inventoried and reviewed documentation.

Table 1: PSNY Relevant Passenger Circulation and Access Improvement Efforts.

2.6 PCIP Document Catalog

Management of the data gathered and focusing data collection on the information most relevant to the PCIP Study, was a key effort for this study. The Study Team compiled a significant volume of information regarding the built environment surrounding PSNY as well as relevant PSNY improvement and development plans. To ensure that the PCIP work efforts provide value to NJ TRANSIT in future efforts and to facilitate the organization and access of the documentation gathered, a basic database of information was developed: the PCIP Document Catalog.

Several different database framework and structure alternatives were considered and evaluated. Based on the purpose and requirements of the tool, it was determined that a Macro-based Excel spreadsheet would be an appropriate solution as it provides the most flexible format, minimizes special software and training requirements and has the desired functionality. The developed Excel spreadsheet has filtering, searching and printing capabilities and for each document it includes the fields listed below.

- Owner
- Project Name
- Project Stage (as of 2018)
- Year
- Document Description

- Design Level
- File Name
- File Type
- Developed by
- Folder Link
- Tab Reference
- Website Link

When applicable and when the information was available, these two fields were also recorded:

- Coordinate System
- Vertical Datum

In addition, all the documents were organized by project. To facilitate the use of the database the below project specific information was recorded and summarized on each project tab in the Excel spreadsheet database.

- Owner
- Project Name
- Project Stage (as of 2018)
- Project Type
- Main Engineering Firms Involved
- Website Link
- Folder Link
- Brief Description
- Project Map

The effort has organized and registered more than 100 entries of relevant documentation into the database. The final database that includes all the documentation collected for this Study is delivered with this Final Report.

LTK & Arup prepared a user manual that provides an overview of the tool and its functionality that can serve as a standalone document to be distributed to NJ TRANSIT users. The user guide not only provides guidance on how to use the tool, but also provides instructions on how to include additional information in the database so that NJ TRANSIT can build upon the work completed under the PCIP Study. The database "User Guide" was issued for NJ TRANSIT as a separate deliverable and is also included in this report as Appendix E.

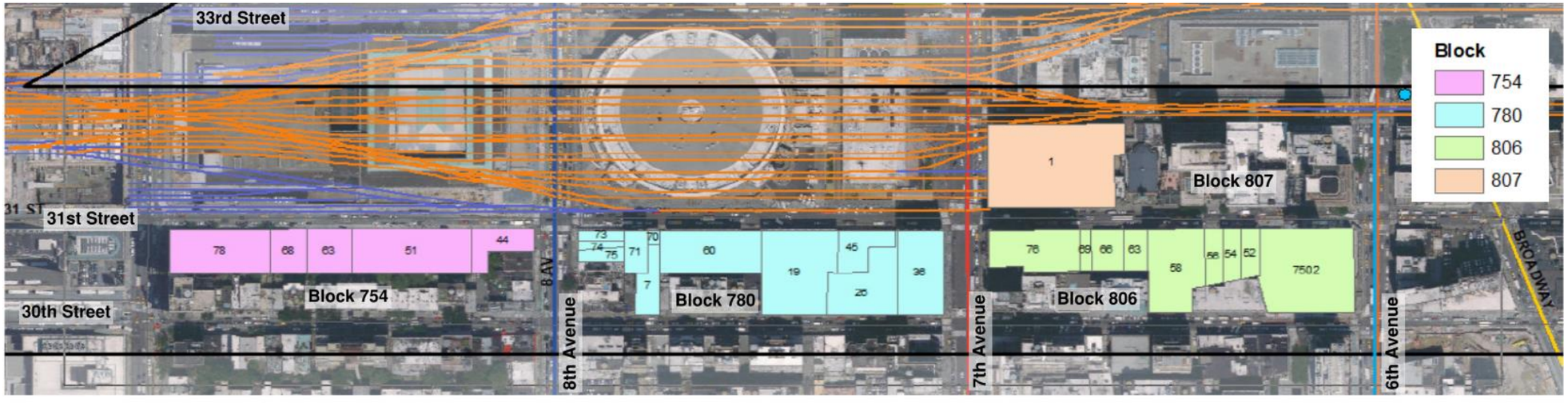
2.7 General Observations

The review of the documentation gathered and inventoried as part of Task 1 effort yielded the following insights regarding the current and future Penn Station built environment and the development of potential alternatives within the scope of this PCIP Study:

- One of the significant challenges with studying improvements at Penn Station is the sheer volume of information available given the age of the station and the numerous projects that are relevant to this effort.
- Management of the data gathered and focusing the data collection effort on the information highly relevant to the PCIP Study was a key effort of the PCIP study.
- Potentially feasible infrastructure alternatives that will expand NJ TRANSIT track and platform capacity at PSNY are considerably limited due to the space constraints imposed by the existing and planned physical built environment.
- Available space underneath the 31st Street right of way is considerably limited and potential alternatives to develop additional tracks and platforms south of Track 1 would require important modifications in the retaining wall and their feasibility would be significantly influence by the existing basement and foundation configuration of the buildings on the south side of 31st Street.
- The feasibility and value of an eastward extension of Platforms 1 and 2 and Tracks 1-4 is greatly constrained by the 11 Penn Plaza office building.

In conclusion, this chapter has summarized the work performed under PCIP Task 1 and has discussed the data collection effort, provided an overview of the documentation inventoried, discussed the main projects relevant to this study, summarized the critical constraints surrounding Penn Station and described the PCIP Document Catalog developed. The definition of an approach to alternatives development and alternatives evaluation as well as the development and evaluation of the potential PCIP alternatives was performed under Task 3, 4 and 5, and it is properly documented in the following chapters of this report, as well as the recommendations resulting from this effort.

Borough	Block	Lot	Zip Code	Address	Bldg. Class	Building Type	Owner Name	Lot Area	Bldg. Area	Com. Area	No. Floors	No. Basements	Year Built
MN	754	40	10001	411 8 AVENUE	K4	PREDOMINANT RETAIL WITH OTHER USES	411 RIGGIO LLC	2469	6520	6520	4	1	1989
MN	754	41	10001	413 8 AVENUE	K4	PREDOMINANT RETAIL WITH OTHER USES	413 RIGGIO LLC	2469	7109	7109	4	1	1989
MN	754	44	10001	415 8 AVENUE	G6	LICENSED PARKING LOT	KEDEM REALTY 415 LLC	8636	0	0	0	0	NA
MN	754	51	10001	320 WEST 31 STREET	W3	SCHOOL OR ACADEMY	OVERTIME PROPERTIES L	25912	116000	116000	4	1	1953
MN	754	63	10001	340 WEST 31 STREET	G1	ALL PARKING GARAGES	POST OFFICE GARAGE,	9875	82750	82750	8	2	1972
MN	754	68	10001	350 WEST 31 STREET	O6	OFFICE WITH COMM - 7 TO 19 STORIES	APWU LOCAL 10 BLDG CO	7900	63200	63200	8	1	1924
MN	754	78	10001	362 9 AVENUE	O6	OFFICE WITH COMM - 7 TO 19 STORIES	TEACHERS INSURANCE AN	21725	338962	338962	16	1	1931
MN	780	7	10001	259 WEST 30 STREET	L1	LOFT; OVER 8 STORIES (MID MANH. TYPE)	TWO FRIENDS RELTY	6540	90174	90174	17	1	1928
MN	780	19	10001	225 WEST 30 STREET	G1	ALL PARKING GARAGES	NEW GARDEN GARAGE	30957	245542	245542	6	0	1957
MN	780	26	10001	209 WEST 30 STREET	M1	CHURCH, SYNAGOGUE, CHAPEL	CH ST JOHN BAPTIST	19550	30000	30000	4	1	1920
MN	780	36	10001	370 7 AVENUE	O6	OFFICE WITH COMM - 7 TO 19 STORIES	370 SEVENTH AVENUE FE	19750	332383	332383	17	3	1921
MN	780	45	10001	204 WEST 31 STREET	M9	MISCELLANEOUS RELIGIOUS FACILITY	THE PROVINCE OF ST MA	9066	23110	23110	3	1	1974
MN	780	60	10001	232 WEST 31 STREET	U6	RAILROAD - PRIVATE OWNERSHIP	NATIONAL RAILRD PSNGR	22219	NA	NA	5	3	1900s
MN	780	70	10001	252 WEST 31 STREET	O5	OFFICE WITH COMM - 1 TO 6 STORIES	252 WEST 31 ST. CORP	866	4062	4062	5	1	1930
MN	780	71	10001	254 WEST 31 STREET	O6	OFFICE WITH COMM - 7 TO 19 STORIES	THIRTY ONE CO	4937	65977	65977	15	1	1926
MN	780	73	10001	416 8 AVENUE	K2	MULTI-STORY RETAIL BUILDING (2 OR MORE)	416 8TH OWNER, LLC	2325	4600	4600	2	1	1930
MN	780	74	10001	414 8 AVENUE	K1	ONE STORY RETAIL BUILDING	414 ENTERPRISES, INC.	1980	2008	2008	1	1	1920
MN	780	75	10001	412 8 AVENUE	K4	PREDOMINANT RETAIL WITH OTHER USES	A.M.A.A. REALTY CORP	2917	11150	11150	7	1	1930
MN	806	52	10001	116 WEST 31 STREET	H3	LIMITED SERVICE; MANY AFFILIATED WITH NATIONAL CHAIN	HCIN HERALD SQUARE AS	4379	49286	0	18	4	2003
MN	806	54	10001	120 WEST 31 STREET	O6	OFFICE WITH COMM - 7 TO 19 STORIES	MONTANA BAY INC	5100	32540	32540	7	NA	1920
MN	806	56	10001	124 WEST 31 STREET	G6	LICENSED PARKING LOT	124 WEST 31 ST STREET	5103	0	0	0	0	NA
MN	806	58	10001	128 WEST 31 STREET	O6	OFFICE WITH COMM - 7 TO 19 STORIES	VBGO PENN PLAZA FEE L	23050	384655	384655	17	2	1925
MN	806	63	10001	140 WEST 31 STREET	O5	OFFICE WITH COMM - 1 TO 6 STORIES	1-S REALTY CORP	4900	17923	17923	4	1	1926
MN	806	66	10001	142 WEST 31 STREET	Y1	FIRE DEPARTMENT	FIRE DEPARTMENT	7417	10000	10000	3	1	1947
MN	806	69	10001	148 WEST 31 STREET	G6	LICENSED PARKING LOT	CYH MANHATTAN LLC	2419	0	0	0	0	NA
MN	806	76	10001	371 7 AVENUE	H1	LUXURY HOTEL	CYH MANHATTAN LLC	19011	473391	22500	28	5	1929
MN	806	7502	10001	855 AVENUE OF THE AMER	RM	MULTIPLE RESIDENTIAL CONDO UNIT	THE DURST ORGANIZATION	39700	434250	179553	41	5	2014
MN	807	1	10001	393 7 AVENUE	O4	OFFICE ONLY WITH OR WITHOUT COMM - 20 STORIES OR MORE	VORNADO ELEVEN PENN P	57675	1103075	1103075	26	3	1926



Source: Developed for the PCIP Study based on the information available on the NYC Department of Buildings and on the NYC Open Data Portal.

Figure 6: Relevant Buildings South of 31st Street Summary.

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3 Development of Study Base Map and Information Graphics (Task 2)

3.1 Project Base Map Development

Based on the inventory and compilation of data performed under Task 1, a high-level base map was developed that defined the existing and planned physical built environment envelope into which potential conceptual alternatives that would improve capacity at PSNY could be developed. The base map level of detail was dictated by information gathered and budgetary constraints, but its level of detail is sufficient to validate feasibility of alternatives at the conceptual level.

The base map clearly defines the physical constraints and the available envelope within which adding new track and platform capacity might proceed, including potential extensions of exbasisting Tracks 1-4 and extension/tail tracks of some or all of the new tracks identified as part of this study. The base map includes key elements of PSNY including the approximate location of tracks, platforms, columns, concourses, streets, curbs, buildings footprints, etc.

A project-specific survey was not performed as part of this work. Base map information was developed from multiple sources developed for other projects and obtained from NJ TRANSIT and Amtrak. A list of the survey files used, and the limitations of the base map developed are described in this section.

3.1.1 Compiled Data and Sources

Building_Footprints - Data is from then NYC Open Data website and it was clipped to the project general area. Ground floor elevations and roof height values are in rounded NAVD88, feet. For the base map, the elevations (Z_Elev_New) are for the ground elevation converted to the Hudson River Tunnel Project (HRT) vertical datum at the centroid of the building.

PS_Columns_Line - Extracted from the All.DGN file (concrete or steel columns). Vertical elevations were extracted from creating a raster surface from the platform edge and center elevations. The elevation was then converted to HRT datum and applied to the center of the line.

PS_Tracks - Extracted from the All.DGN file. This data represents the survey shots for ground or rail in PSNY. Data was used to generate a raster surface for the ground and rails and to update rail lines start and end elevations through a spatial join. Tracks were adjusted on the west side (F tracks) and on the east side (Tracks 1-4) using data sent to Matrix on 08/29/2018 (PSCE 30% Design, PSNY Central Concourse 2012 Survey, PSNY Vision Study Existing Plans).

PS_Outer_Walls - Extracted from the All.DGN file. Original data were long line segments representing the north and south walls. The walls were segmented into 50-foot sections and the ground raster surface (created above) was used to populate the starting and ending elevations of

each segment. Wall alignment was adjusted using data sent to Matrix on 08/29/2018 (PSCE 30% Design, PSNY Central Concourse 2012 Survey, PSNY Vision Study Existing Plans).

PS_Platform_(Line/Point) - Extracted from the All.DGN file. Elevation data for the platforms ended about halfway down the platforms (west to east). The linework was there, so a known elevation from a survey conducted by Matrix for a different project was used, calculated an average rise from center to end, and applied that to every platform. Platform alignments and elevations were adjusted using data sent to Matrix on 08/29/2018 (PSCE 30% Design, PSNY Central Concourse 2012 Survey, PSNY Vision Study Existing Plans).

PS_Tracks_Line - Extracted from the All.DGN file. As with the platforms above, the tracks elevation information ended midway through the platforms. Tracks 1 through 4 were updated with information sent to Matrix in PDF form (NJT_PSCE_PE 30% Deliverable_DRAWINGS Task 2_03_30_2007.pdf). Where reliable spot elevations were not available, a subtraction from adjacent platform elevations were extrapolated to the entirety of the tracks to the east end of PS NY. The PS_Ground_Tracks data from above was also utilized to perform a spatial join for the start and end of the track segments, providing more accurate and smoother track linework.

PS_Utilities_(Line/Point) - Extracted from the All.DGN file.

Subway_Entrances_Pts - Street level subway entrances were downloaded from Neuman Library GIS Lab. Elevation of these entrances were extrapolated from the Floating Points 1-foot DEM, described below.

Surface_DEM_Contours - One-foot contours created from the Floating Point 1-foot Digital Elevation Model (2010 LiDAR) downloaded from NYC Open Data. Raster grid was clipped, and elevations converted from NAVD88 to the HRT project elevation. Where the contours intersected buildings, those contours were removed.

Tax_Parcels - Parcels were downloaded from NYC Planning and clipped to the project area. Elevations were applied using the centroid of the parcels and extracting from the DEM.

Subway_Rail_NYCT - From the HRT project, linework depicting subway and train lines in Manhattan. Very generalized, and sometimes wrong, elevation data. The tracks that were redundant to the PS Tracks information already obtained were deleted. The subway lines were given the elevation from the rail elevation spreadsheet developed by Arup based on the historical NYCT drawings obtained from the NYCT archives. Where the linework was off near the east side of PSNY, the lines were altered to meld better with the PS data.

Water_Tunnel - Data was pulled from the HRT Manhattan Supplemental Survey. The entire tunnel linework was merged into one single line and the elevations were applied to the start and the end.

Level_A_Polyline - Layer generated using data sent to Matrix on 08/29/2018 (PSCE 30% Design, PSNY Central Concourse 2012 Survey, PSNY Vision Study Existing Plans).

Level_B_Polyline - Layer generated using data sent to Matrix on 08/29/2018 (PSCE 30% Design, PSNY Central Concourse 2012 Survey, PSNY Vision Study Existing Plans).

PS_Stairs - Extracted from the All.DGN file. Vertical elevations were extracted from creating a raster surface from the platform edge and center elevations. The elevation was then converted to HRT Datum and applied to the center of the line.

Track_Ground_Spot_Elevations - Point data layer originally from All.dgn. A few points were added on the east end of Tracks 1-4, using data sent to Matrix on 08/29/2018 (PSCE 30% Design, PSNY Central Concourse 2012 Survey, PSNY Vision Study Existing Plans).

Track_Ground_Elevations_Anno - Annotation related to Track_Ground_Spot_Elevations.

Platform_Spot_Elevations - Point data layer originally from All.dgn. A few points were added on the east end of Tracks 1-4, using data sent to Matrix on 08/29/2018 (PSCE 30% Design, PSNY Central Concourse 2012 Survey, PSNY Vision Study Existing Plans).

Platform_Spot_Elevations_Anno - Annotation related to Platform_Spot_Elevations.

Amtrak_Service_Building - Linework was extracted from PSNY Vision Study Existing Plans, sent to Matrix on 08/29/2018. Elevations were generalized from surrounding wall elevations

Utilities_9th_31st_(Point/Line) - Utility data sent to Matrix from ARUP. No elevation information existed in the dataset, so elevations were derived by subtraction 1 foot from the nearest DEM surface elevation.

3.1.2 Coordinate Systems

The horizontal projection for all data is New Jersey State Plane NAD83 FIPS 2900 US Feet. The system of measurement is English units (US Survey Foot).

The vertical data is in THE PROJECT datum, converted from NAVD88. The vertical datum is the Pennsylvania Railroad Tunnels Datum. This datum was selected to facilitate coordination with the Hudson River Tunnel project. This datum is set 199.928 feet below the New York City Transit (NYCT) Authority datum. All elevation data should be taken from the Z_Elev_New, Z_Start_New, or Z_End_New fields in each dataset.

3.1.3 Limitations

A project specific survey was not performed as part of this work. Base map information was developed from multiple sources developed for other projects and obtained from NJ TRANSIT and Amtrak. A list of the survey files used is provided in the section above.

Matrix used the available information to develop a high-level base map with sufficient details to support the development of the conceptual alternatives of this project. Where reliable elevation data was not available as part of the information contained within supplied MicroStation or CAD drawings, elevations were derived by creating raster surfaces with available data. The datasets used were in one of three horizontal datums (New Jersey State

Plane 2900, New York Long Island 3104m or "Drawing Space"). The drawing space data, which was basically drawn on a flat plane, was transformed using known coordinates related to the grid system laid out in the Baseline.DGN. A world (.WLD) file was created to complete this transformation.

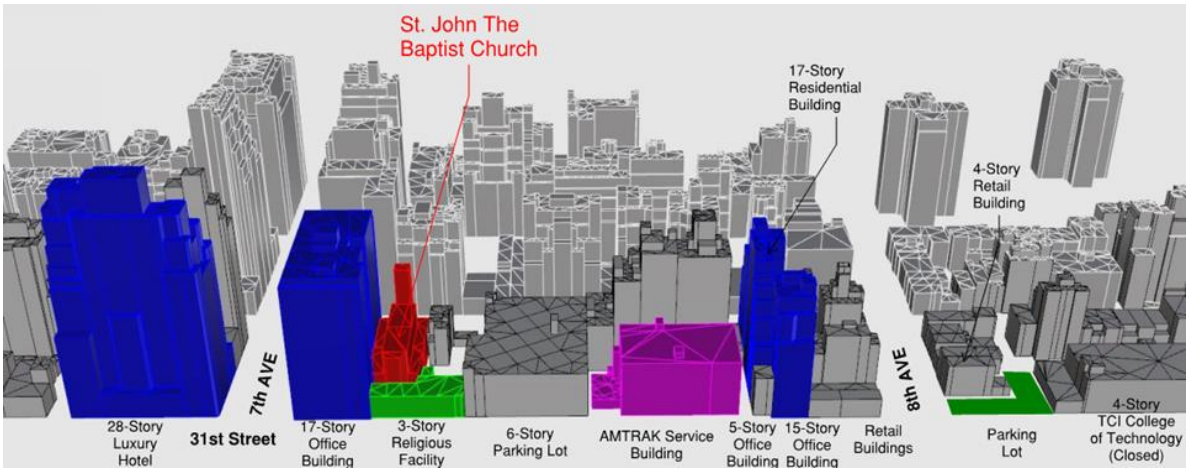
Discrepancies were found to exist between the different survey files and record drawings considered and utilized to develop the project base map. In addition, since some existing information was drawn from original drawings, post-construction revisions or alterations are not necessarily reflected in the project base map.

Due to the limitations of the data considered, a full survey of all existing conditions in the project area shall be performed in the next stage of the design to accurately portray the current relationship of all structures and to adequately support the engineering work.

3.2 Project Visual 3D Model

A 3D model was developed in conjunction with the base map to facilitate understanding the existing spatial constraints. While the project base map incorporated the relevant data as described in the previous section, when considering an expansion project or performing a feasibility study, a 3D model is very helpful, especially in an urban setting like in this case.

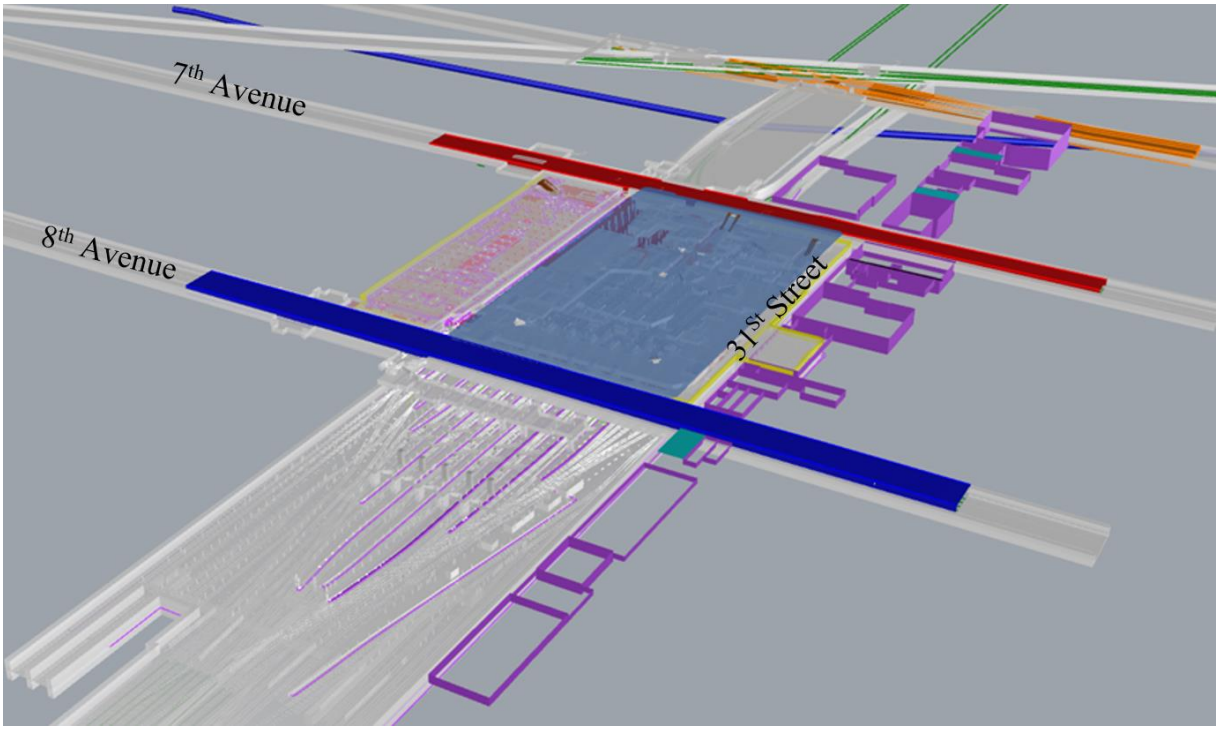
The development of the 3D model started with the base map. The base map provided polylines (2D) for the key elements (platforms, buildings, tracks, concourses, etc.) at the appropriate elevations. For example, the track centerlines are below the street elevations. The 2D features were extruded and developed to form 3D shapes that are geometric interpretations of existing features. Historic information was also incorporated as available. The 2D lines denoting the location of elements such as the retaining wall along 31st Street were extruded and shaped as appropriate to provide the dimensions of the existing wall. This helped inform decisions such as constructability and track layout. Figure 7 shows the existing key buildings south of 31st Street. Being able to categorize the buildings visually aided the identification of constraints.



Source: 3D Model developed for the PCIP Study based on documentation and data compiled.

Figure 7: Existing Key Buildings South of 31st Street.

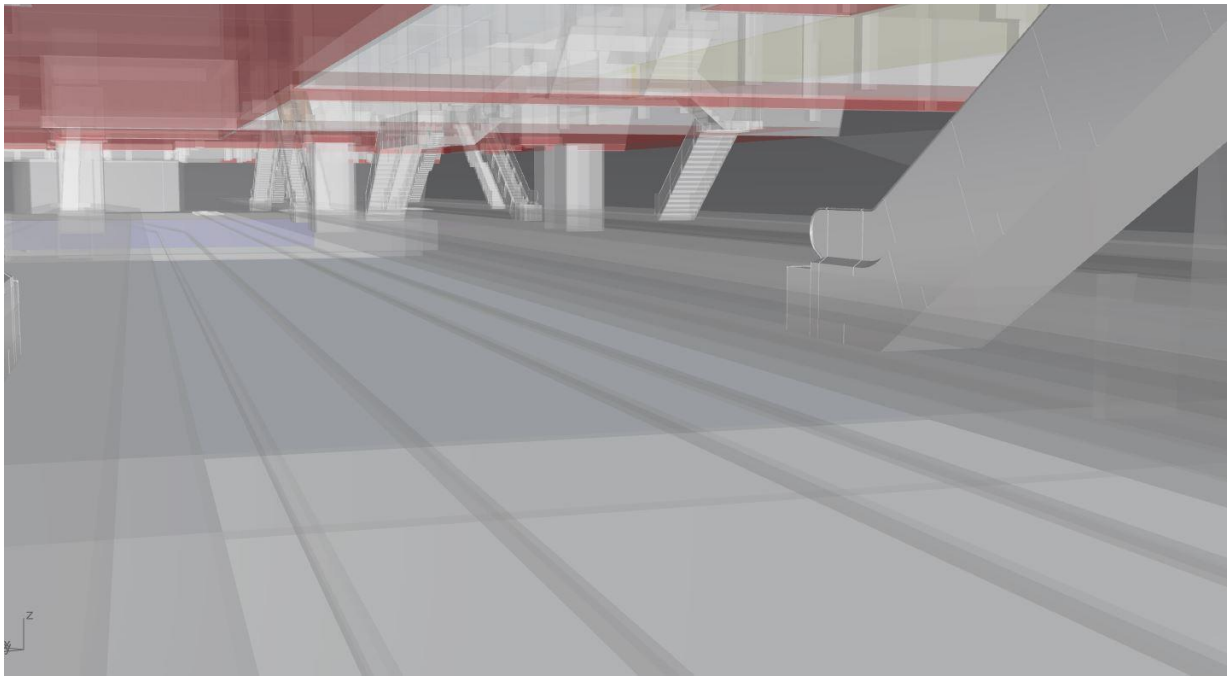
Through coordination with NJ TRANSIT and Amtrak, a 3D model was also received that had been previously developed by STV under a different project (Amtrak – Task 8 Penn Station District Planning) and incorporated into the PCIP 3D model. The STV model contains detailed track and platform levels. Additionally, the opensource data from NYC that contains building volumes was added. These helped influence design and further understand existing spatial constrains and areas of potentially higher risk. Figure 8 illustrates the track layout and estimated basements and foundations from the buildings. The retaining wall is also shown.



Source: 3D Model developed for the PCIP Study based on documentation and data compiled.

Figure 8: PCIP 3D Model View of Tracks and Buildings along 31st Street.

Furthermore, the PCIP 3D model developed was used to easily visualize the existing built environment near PSNY and it was important for collaboration with the different disciplines working on the project (Structural, Geotech, Rail, etc.) Figure 9 shows the existing stairs and columns. This layer of the model helped the structural team understand which columns supported which beams and how the area can be altered. The model aided both development of the rail and structural design as well as provided additional insight to better understand the constructability issues regarding this complicated urban setting.



Source: 3D Model developed for the PCIP Study based on documentation and data compiled.

Figure 9: 3D Model View of the Details at Track and Platform Levels.

4 Approach to Alternatives Development and Alternatives Evaluation (Task 3)

This section documents the alternatives evaluation method used to comparatively assess competing alternatives in an objective and professionally defensible manner. The alternatives evaluation method was developed in consideration of:

- PCIP Study goals and objectives
- Existing NJ TRANSIT and PSNY constraints and challenges
- Level of detail available for alternatives
- Engineering and operational criteria
- Project delivery requirements and constraints
- Project stakeholders
- Compatibility of alternatives with other planning alternatives in and around PSNY
- The likelihood that various alternatives may not be comparable
- The possibility that a grouping of complementary alternatives may be identified as recommended to advance.

Delivery of even relatively minor projects at PSNY can be difficult given the intensity of operations and pedestrian activity at the station and given the numerous stakeholders and planned projects in and around PSNY. Hence, advancing projects to improve PSNY normally requires development of a high level of detail and intensive stakeholder coordination. Based on the highly conceptual nature of the PCIP Study, the alternatives evaluation method necessarily focuses on the major issues and those that can be assessed using a combination of high-level quantitative metrics and professional judgement on potential benefits and impacts. The alternatives evaluation method was developed to meet this need, and to focus LTK & Arup resources on the development of alternatives definition that would allow NJ TRANSIT to make well informed decisions regarding how best to advance the work of the PCIP Study.

This section of the report documents the study evaluation criteria and method used to screen alternatives, to highlight impacts, and to weigh benefits. The proposed criteria are sufficiently broad to evaluate not only whether a given alternative meets the defined need and the study goals and objectives, but also the concerns of NJ TRANSIT stakeholders.

4.1 Alternatives Evaluation Approach

This planning study is unique in that a single preferred alternative was not identified as the recommendation for advancement, and that all the alternatives considered were not necessarily comparable against one another. The alternatives evaluation method necessarily considered

that some alternatives are geared toward different goals or fit within significantly different timeframes or cost scales. Therefore, the evaluation identified first if the alternative is recommended to advance, and second how those alternatives recommended for advancement should be "categorized". Categorization of recommended alternatives was performed after initial evaluation and addressed issues such as near versus long term, low versus high cost, and dependency on or ability to integrate with or enhance other planned projects such as Gateway.

Given the complexity and potential high costs and impacts of infrastructure alternatives within PSNY, and the numerous alternatives previously considered by NJ TRANSIT or currently in the planning stage, LTK & Arup started with a preliminary screening of a greater number of alternatives during alternatives development in close coordination with NJ TRANSIT. Once alternatives were developed to a point that allowed for preliminary screening against project goals and objectives, the Study Team worked with NJ TRANSIT to focus efforts on the most promising alternatives. These efforts advanced the shortlisted alternatives to include the level of detail required to undergo the more comprehensive evaluation approach.

The method used to evaluate alternatives consisted of two phases as follows:

4.1.1 Phase 1 – Alternatives Definition

This preliminary screening effort involved the following key efforts. If an alternative passed the following checks it was advanced to Phase 2.

- Spatial Feasibility: A preliminary analysis to determine if the space exists to accommodate a proposed infrastructure alternative. This verified general requirements such as platform length and width, adequate cover to bedrock for tunneling, and other critical clearances to ensure that the alternative would be constructible within reasonable limits.
- Design Criteria Compatibility: A preliminary analysis of each alternative was undertaken to confirm if the alternative can be delivered within standard design criteria requirements.
- Study Goals and Objectives: Study alternatives proposed were evaluated for their potential to improve overall capacity, frequency, and reliability; to improve pedestrian connectivity and accessibility; to complement or support other planned projects in and around PSNY; and, to be delivered within the broad schedule and budgetary goals of the PCIP study.

4.1.2 Phase 2 – Alternatives Evaluation

This phase involved the detailed evaluation of those shortlisted alternatives advanced.

Alternatives advanced to the Alternatives Evaluation Phase were developed to a sufficient level of detail to undertake the evaluation. In keeping with the exploratory nature of the requested work, the level of detail developed for each alternative is limited but was sufficient to estimate the potential passenger and train capacity benefits, to define the general infrastructure configuration, and to confirm feasibility of construction. The detail developed was also sufficient to communicate the proposed alternatives to NJ TRANSIT management, to allow for an assessment of operational feasibility and potential environmental and property impacts, to

support development of comparative capital cost estimates and construction schedules, and ultimately to support a NJ TRANSIT decision regarding which alternative or group of alternatives should be advanced.

4.2 Alternatives Evaluation Method

A broad array of both quantitative and qualitative evaluation criteria was considered in the evaluation of alternatives. Alternatives were evaluated across 23 separate criteria covering both alternative implementation or project delivery and the performance considerations for each alternative. Based on the results of the analysis, a red, yellow, or green value was assigned to each alternative for each evaluation category to create a "stoplight chart". Stoplight colors are assigned the following values: Red = 1, Yellow = 2, Green = 3

This tool is frequently used because it supports both a visual and quantitative comparative analysis. In this context, quantitative means an ordinal ranking of 1, 2, or 3. This separates the analysis from purely quantitative values such as capital costs and allows alternatives judged to be equal in a specific criterion to be given the same ranking. The "stoplight chart" approach was also adopted since it is not practical to perform an overall quantitative ranking of alternatives when various criteria cannot be quantified through technical analyses, ranking of alternatives for some criteria require professional judgement, and the various criteria are not additive.

For each evaluation metric, an assessment was made both in terms of the overall "value" of the metric and its comparative "ranking" where applicable. A comparative assessment to other alternatives may only be applicable in certain cases, such as alternatives providing new platform edges. A qualitatively or quantitively justification for the scores assigned to each metric was included as part of the results of the evaluation assessment.

The evaluation metrics were grouped, and the proposed method and stoplight chart allows a weighting approach that can be applied to individual metrics, and to each group. This possible "two-dimensional" weighting approach allows for the screening to focus more heavily on specific metrics relative to other similar metrics in the same category of evaluation, and account for the fact that certain evaluation metrics can heavily influence the overall viability of an alternative while other considerations, albeit important, could be mitigated through site specific design and construction approaches at significantly lower costs relative to the overall scale of the alternative.

Figure 10 illustrates the proposed Stoplight Chart evaluation and screening tool. The weighting values, the scores and the alternatives shown are arbitrary and provided for illustration purposes only.

Weighting for the various evaluation criteria were determined through professional judgment and previous experience, in close coordination with NJ TRANSIT, in consideration of the effect that each specific criterion had on the relative deliverability and benefit of the alternatives. This allowed for consideration of those evaluation metrics with the most significant impact on viability of the alternative, such as construction cost and operational

impacts. In each Evaluation Group, the number of red, yellow, and green values was tallied to arrive at an overall total. This total value was then normalized by dividing the total tally by the number of evaluation criteria in each specific category (and rounded to the nearest tenth).

Alternatives Evaluation Summary Chart			PCIP Alternatives - SAMPLE EVALUATION		
			Alt 1	Alt 2	Alt 4
Implementation	Weighting	Weighted Tally	24	46	36
		Normalized Tally	1.3	2.6	2.0
	2	Engineering Complexity	1	3	1
	1	Design Criteria Compatibility	1	2	3
	2	Operational Impacts	1	3	2
	1	Station Impacts	2	1	1
	2	Property Impacts	1	2	3
	1	Environmental Impacts	3	3	2
	1	Regulatory Process Requirements	1	3	3
	1	Stakeholder Requirements	2	3	1
	2	Constructability	1	2	3
	2	Risk	1	3	1
	2	Capital Construction Cost	1	3	2
	1	Construction Schedule	3	2	2
Performance	Weighting	Weighted Tally	26	28	23
		Normalized Tally	2.4	2.5	2.1
	Customer Focused				
	1	Reliability	3	2	1
	1	Service Plan - Frequency	3	2	2
	1	Pedestrian Connectivity	3	1	1
	Operational Focused				
	2	Operational Capacity	1	1	1
	1	Operations & Maintenance	2	3	1
	2	Passenger Capacity	1	2	2
	Program Focused				
	1	Environmental Sustainability	2	2	2
	2	Cost Recovery	1	3	3
	1	Resiliency	2	1	2
	1	Compatibility with Planned Projects	3	2	1
	1	Project Based Value	2	3	1
	Weighting	Group	Results Summary		
	1	Implementation Considerations	1.3	2.6	2.0
	1	Performance Considerations	2.4	2.5	2.1
	FINAL Alternative Score		1.8	2.6	2.0

Source: Developed for the PCIP Study.

**The weighting values, the scores and the alternatives shown are arbitrary and provided for illustration purposes only.*

Figure 10: Proposed Stoplight Evaluation Chart and Screening Tool.

Evaluation category totals for both the "Implementation Considerations" and the "Performance Considerations" categories were then added to arrive at an overall score for each alternative. The overall rating was determined for each alternative.

In addition to the Stoplight Chart evaluation and screening tool, a Scatter Plot provides a summary comparison of the scoring of alternatives using a single plot point for each alternative. The goal of the alternatives evaluation effort was to not only provide NJ TRANSIT with the information required to make well-informed and defensible decisions regarding which alternative to move forward, but also with a means to best communicate study results to a broad group of internal and external stakeholders. While the Stoplight Chart provides a great deal of information to support comparative analysis of competing alternatives, it can be hard to digest the amount of information provided. The Scatter Plot allows for rapid comprehension of the evaluation results. Those alternatives with significant benefit and straightforward project delivery are readily identified as falling into the upper righthand quadrant. The range of values on the axes are scaled differently to represent the resulting range of Normalized Tallies shown in the Implementation and Performance Categories of the Stoplight Chart.

4.3 Alternatives Evaluation Metrics

Given the highly conceptual nature of study, the alternatives evaluation method focused on major issues that could be comparatively assessed using a combination of high-level quantitative metrics and qualitative criteria assessed based on professional judgement and experience on previous projects of similar characteristics. The evaluation metrics considered included are described below and were divided into two categories, Implementation Considerations and Performance Considerations, basically what it would take to deliver the project and what the project would deliver in terms of benefits.

4.3.1 Implementation Considerations

Those metrics related to the issues associated with delivering the design and construction of the proposed alternative were identified as Implementation Considerations.

- Engineering Complexity: This metric addresses the engineering complexity of the proposed alternative in terms of the scale proposed and the expected challenges that would be faced to design the alternative in a way that meets various performance goals and code requirements. The score focuses only on the key elements of each alternative and specific engineering complexity issues. The value for this metric was assigned using professional judgment depending on the assessment of the engineering complexity issues relative to all alternatives. Lower scores are given to more complex alternatives.
- Design Criteria Compatibility: This metric addresses considerations regarding an alternative's ability to comply with standard design criteria or industry guidelines. Professional judgement is used to assess each alternative across a broad range of considerations, including track alignment, accessibility and egress capacity. If critical design criteria cannot be met, the alternative was screened out during the Alternatives Definition Phase as described above. This metric captures consideration of "softer" design

issues, such as the use of less desirable No. 8 turnouts (in lieu of No. 10 turnouts), clearance restrictions, or platform widths that meet code requirements but are less than desirable. The value for this metric was assigned using professional judgement depending on the assessment of the design criteria compatibility issues relative to all alternatives. Lower scores are given to alternatives requiring significant deviation from desirable design criteria.

- Operational Impacts: This metric addresses the expected operational impacts that would occur during construction or operation of the alterative. The value for this metric was assigned using professional judgment depending on the assessment of expected operational impacts relative to all alternatives. Lower scores are given to alternatives with greater impact.
- Station Impacts: This metric addresses the expected pedestrian circulation and station operations impacts. The value for this metric is assigned using professional judgment depending on the assessment of expected station impacts relative to all alternatives. Lower scores are given to alternatives with greater impact.
- Property Impacts: This metric addresses the general extent and type of real estate required for the alternative or impacts to existing properties or businesses. Existing properties impacted are assessed using judgement on current or projected use of the property and the surrounding area. The value for this metric was assigned using professional judgment depending on the assessment of expected property impacts relative to all alternatives. Lower scores are given to alternatives with greater impact.
- Environmental Impacts: A detailed environmental impact analysis is not within the scope of the PCIP study, but this metric addresses expected project-specific and cumulative changes to the physical environment that would result from the alternative. It is not expected that study alternatives would significantly change such things as air quality, energy usage, or other normal metrics. However, professional judgement and publicly available data are used to assess potential impacts to environmentally sensitive resources such as historic properties, cultural resources, or hazardous materials sites. Lower scores are given to alternatives with greater impact.
- Regulatory Process Requirements: This metric addresses the expected regulatory approval processes required to advance the alternative. Professional judgement is used to identify the extent to which the alternative would require detailed environmental impact analyses, U.S. Army Corp permits, or other such rigorous review and approval requirements. Projects that could be expected to advance through a streamlined process are given higher scores.
- Stakeholder Requirements: This metric addresses issues associated with gaining project approval from various potential stakeholders and regulatory bodies. Advancing any significant improvements to PSNY would require close coordination with Amtrak and various other stakeholders, but this metric is intended to capture the comparative difficulty expected to gather input and reach agreement amongst alternatives. Meeting demands of stakeholders can significantly affect the design development and approval schedule, as well

as the alternatives delivery costs and schedule. Issues associated with stakeholder considerations include degree of cooperation, interpretation of stakeholder's design criteria and procedures, likely requirements for betterments to stakeholder properties, and stakeholder assignment of dedicated staff to assist on design and construction issues. Lower scores are given to alternatives that would require coordination and approval by more stakeholder groups, or those that can be expected to generate greater resistance given impacts.

- Constructability: This metric addresses the expected degree of difficulty in constructing the alternative; the greater the expected construction difficulty, the greater the risk of cost or schedule impacts. Alternatives requiring special construction approaches (including types of equipment and construction skills) would be costlier to deliver and construction schedules would be extended. While construction of any alternative at PSNY will involve specialized and complicated construction, the evaluation metric ranks relative magnitude of potential complicated and risky construction required relative to all alternatives. Higher scores are given to alternatives with relatively straight-forward construction.
- Risk: This metric addresses the major factors and issues that could negatively impact the ability to develop a workable design or could make delivery of the project risky in terms of construction cost or schedule. Major risks were identified and the greater the number of factors and issues associated with an alternative the greater the risk of successful project delivery. Professional judgement is used to rank alternatives depending on the identified risks unique to each alternative that are greater or more complex than anticipated risks for all alternatives and for this type of project.
- Capital Construction Cost: This metric addresses the estimated capital construction costs for the heavy infrastructure elements of the project. Order of magnitude costs for each shortlisted alternative were developed. The order of magnitude costs were tallied and normalized by dividing each alternative's estimate by the minimum cost for any alternative.

  (Alternative A Normalized Total = [Alternative Cost]/[Lowest Alternative Cost])

  Alternative costs were then ranked by creating a 1/2/3 rating based on whether the alternative fell within the lowest third, middle third, and upper third of the range among all alternatives. If any alternative's cost is a clear outlier, the analysis did not include that alternative in development of the range used to classify the lowest, middle, and upper thirds.
- Construction Schedule: This metric addresses the expected delivery time of each alternative. As part of the study, a high-level estimate was developed for the planning, design, regulatory approval and construction schedule for each shortlisted alternative. Delivery schedules for each alternative were then normalized in an approach similar to that described for capital construction costs.

4.3.2 Performance Considerations

Those metrics related to the expected benefits were identified as Performance Considerations. In this category, the various metrics have also been subdivided into focus areas, namely Customer Focused, Operations Focused, and Program Focused metrics.

4.3.2.1 Customer Focused Metrics

Metrics categorized as Customer Focused are intended to capture alternative benefits related to the NJ TRANSIT customer travel experience. The customer experience has always been a concern of NJ TRANSIT, but is becoming increasingly important given changes in travel patterns and demographics in modern society where the convenience of on-demand services like Uber, flexible work schedules, and greater reliance on public transportation is becoming the new norm.

- Reliability: This metric addresses the impact an alternative would provide in terms of increased service reliability and consistency. Professional judgement was used to evaluate each alternative. If applicable, network operations simulation would support quantification of reliability in terms of simulated On Time Performance (OTP). Absent network simulation results, shortlisted alternatives that provide improvements that would increase reliability through greater redundancy, greater availability of track time, or more favorable design criteria are given higher ratings.
- Service Plan – Frequency: This metric addresses each alternative's increase in service frequency. Frequency of service is a very important criterion in most studies of travel choice. Alternatives offering greater frequency of service are rated higher.
- Pedestrian Connectivity: This metric addresses the expected improvement in pedestrian circulation and connectivity for each alternative. The metric also captures each alternative's ability to exceed accessibility and egress capacity requirements. Alternatives that would mitigate existing circulation challenges within PSNY and those that would maximize convenient connectivity to existing and planned development and multimodal connectivity are given higher ratings.

4.3.2.2 Operations Focused Metrics

There is a fine line between operational benefits and passenger experience benefits since improved operations are likely to translate into an improved customer experience. The metrics categorized as Operations Focused relate more directly to NJ TRANSIT operational concerns or the metrics NJ TRANSIT would use to evaluate performance.

- Operational Capacity: This metric addresses the number of NJ TRANSIT trains that can be moved in and out of PSNY under each alternative. This metric also captures operational issues related to the flexibility each alternative provides for operations, such as longer platforms that would eliminate restricted operations to certain platforms, and connectivity to both the existing North River Tunnels and future Hudson River Tunnels. A combination of quantitative measures and professional judgement are used to rate alternatives.

- Operations & Maintenance: This metric addresses the expected benefits, costs, and practices related to operations and maintenance (O&M) for each alternative. Those alternatives that can best help reduce O&M costs, or at least increase O&M costs the least, and those alternatives that help improve O&M practices or require the least changes to current O&M practices are rated higher using professional judgement.
- Passenger Capacity: This metric addresses the number of passengers that can be moved in and out of PSNY based on train operations and consist characteristics. Those alternatives that offer the greatest increase in the number of passengers are rated highest with results normalized.

4.3.2.3 Program Focused Metrics

Those metrics categorized as Program Focus cover more general items related to environmental, urban planning, funding and other concerns.

- Sustainability: This metric addresses NJ TRANSIT's desire to make sustainability a priority in design and operations. Opportunities to incorporate energy-saving features, context-sensitive designs, or green construction techniques are identified. The greater the opportunity to incorporate sustainable design and construction elements into the alternative, or the greater the opportunity to improve sustainability within existing PSNY through the alternative, the higher the alternative is rated.
- Resiliency: This metric addresses resiliency in line with NJ TRANSIT's Comprehensive Resilience Program and mission to provide a stronger public transportation system. Alternatives with greater opportunity to be resilient or that would improve resiliency within PSNY are rated higher.
- Funding and Revenue: This metric addresses the potential funding opportunities represented by each alternative. Opportunities to capture revenue through land development, increased ridership, or joint development are reflected. Professional judgement is used to rank alternatives in terms of the greatest potential to capture existing funding means, those that would be rated high in terms of cost per new rider, or those that offer the greatest possibilities for revenue capture.
- Compatibility with Planned Projects: This metric addresses the compatibility of each alternative with currently planned projects. Alternatives that can best leverage or support currently planned projects are rated highest.
- Independent Utility: This metric addresses the extent to which each alternative independently provides value to NJ TRANSIT and the ability of each alternative to be constructed independent of any other planned projects. Those alternatives that can be provide independent utility and high value, and those that can be advanced separately from other projects are rated highest.

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5 Preliminary Development and Evaluation of Alternatives (Task 4)

This chapter documents the preliminary evaluation of PCIP alternatives. Given that numerous alternatives were identified by NJ TRANSIT and the Study Team, each was developed only to a highly conceptual level given project time and budget constraints. As noted in Chapter 4, preliminary screening efforts focus on spatial feasibility, design criteria compatibility and conformance to Project goals and objectives.

This chapter recommends both infrastructure and operationally oriented alternatives for advancement as part of the PCIP follow-on tasks. Alternatives that were identified as potentially feasible, but outside the goals and objectives of this project, are also identified since they warrant additional development and evaluation under a future study.

5.1 Preliminary Infrastructure Alternatives Description

The following is a list of the infrastructure alternatives considered and evaluated. The appendix of this Final Report includes conceptual plans, sections and profiles developed for each alternative to support this analysis and evaluation.

- Alt 1 & 2: New platforms below Tracks 1-4 connecting via south side of the Diagonal Platform
- Alt 3: New deep-level terminal below PSNY connecting to the bellmouth
- Alt 4: New deep-level terminal under 30th Street connecting to the bellmouth
- Alt 5: Extension of Tracks 1 and 2 below 6th Avenue
- Alt 6: New deep-level terminal below PSNY with revised bellmouth design
- Alt 7: Widening of Platforms 1 and 2
- Alt 8: Widening of Platforms 1 and 2 by eliminating Track 3
- Alt 9: New 31st Street terminal east of 6th Avenue by eliminating Track 1
- Alt 10: ARC feasibility review under new built environment
- Alt 11: Disconnect “U” and “M” Ladders from Tracks 1-4 and construct new “T” Ladder to widen and extend Platforms 1 and 2
- Alt 12: New “T” Ladder serving new platforms on northern portion of Block 780
- Alt 13: Initial phase of Penn Station Expansion Project – Preferred Alt (Concept 9)
- Alt 14: Disconnect “U” and “M” Ladders from Tracks 1-4 and construct new “T” Ladder to extend Platforms 1 and 2 West
- Alt 15: PSCE 30% Design - Eastern and western extension of Tracks 1-4

5.1.1 Alt 1 & 2: New platforms below Tracks 1-4 connecting via south side of the Diagonal Platform

- Development of new tracks and platforms underneath existing Tracks 1-4 connected by reprofiling and realigning existing track along the south side of the Diagonal Platform.
- Alternative 1 includes four tracks and two platforms. Alternative 2 includes two tracks and one platform.
- Considerable impact to "E" Yard.
- Tail tracks could be extended underneath the 6th Avenue Subway and potentially connect to Sunnyside Yard (SSY) in the future. However, grades and rate of change for vertical curves would not be operationally feasible.
- Connecting to the North River Tunnels (NRT) is not feasible due to impact on the Empire Line connection and the additional limitations imposed on the location of grades and vertical curves. This alternative would provide connection only to the Hudson River Tunnels (HRT).
- Alternative would conflict with existing utility tunnels below platforms and would require complete reconstruction of Tracks 1-4 and platforms to allow for "cut-and-cover" construction of new deeper platforms and replacement of existing platforms.
- Alternative deemed infeasible since it would require exceeding Amtrak's maximum allowed profile grade and rate of change for vertical curves and grades required are not considered acceptable from an engineering and operations perspective. (Alternative would require profile grade of 5% and 1.5% rate of change of grade for vertical curves, both of which are infeasible. Amtrak standards are 2% and 0.4% respectively.)

5.1.2 Alt 3: New deep-level terminal below PSNY connecting to the bellmouth

- Development of a new deep-level terminal within the footprint of PSNY and below the existing design (note that this alternative has not been developed as part of the PCIP effort and is included for comparison purposes only).
- Development of new north-south tunnels and access points to provide vertical and horizontal pedestrian circulation.
- Significant challenges associated with construction of new station caverns under an active PSNY.
- Alternative would require completion of the HRT project.
- Originally proposed HRT bellmouth design requires level crossing with one of the HRT mainline tracks, which would be operationally undesirable due to the significant impact on movements throughout the tunnel.

- Tail tracks could be extended underneath the 6th Avenue Subway and potentially connect to SSY in the future.
- Alternative deemed undesirable given bellmouth design and dismissed from further consideration. Alt 6 replaces Alt 3 with proposed bellmouth reconfiguration.

5.1.3 Alt 4: New deep-level terminal under 30th Street connecting to the bellmouth

- Development of a new deep-level terminal underneath 30th Street connected to the bellmouth originally proposed during HRT conceptual design.
- Development of new tunnels and access points to provide vertical and horizontal pedestrian circulation.
- Challenging pedestrian connectivity to PSNY as the location of the station is further south.
- Alternative requires development of HRT project.
- Originally proposed bellmouth design requires level crossing with one of the HRT mainline tracks, which would be operationally undesirable due to the significant impact on movements throughout the tunnel and loss of tunnel capacity.
- Tail tracks could be extended underneath the 6th Avenue Subway and potentially connect to SSY in the future.
- Alternative deemed undesirable given bellmouth design and station location and dismissed from further consideration. (New deep level terminal with reconfigured bellmouth included as Alt 6.)

5.1.4 Alt 5: Extension of Tracks 1 and 2 below 6th Avenue

- Extension of Tracks 1 and 2 under 6th Avenue with new tail tracks under 31st Street, potentially leading back to the HRT bellmouth or connecting to SSY in the future.
- Crossing below the 6th Avenue Subway would require eliminating the eastern extension of Platform 1 proposed with the PSCE project to begin profile descent.
- Alternative dismissed as infeasible given the need to considerably exceed Amtrak's maximum allowed grade and rate of change for vertical curves and grades required are not considered acceptable from an engineering perspective. (Alternative would require profile grade of 7% and 2% rate of change of grade for vertical curves, both of which are infeasible. Amtrak standards are 2% and 0.4% respectively.)

5.1.5 Alt 6: New deep-level terminal below PSNY with revised bellmouth design

- Development of a new deep-level terminal within the footprint of PSNY and below the existing platform level connected to a reconfigured, grade separated, two track bellmouth connection to HRT.
- Development of new tunnels and access points to provide proper vertical and horizontal pedestrian circulation.
- Significant challenges associated with construction of station caverns under an active PSNY.
- Alternative requires development of HRT project.
- Tail tracks could be extended underneath the 6th Avenue Subway and potentially connect to SSY in the future.
- Could potentially be combined with Alts 7 or 8 to develop new bi-level station area on south side of PSNY with lower level served by HRT bellmouth.
- This alternative was reviewed and discarded as part of the ARC alternatives evaluation based on risks associated with construction of a mined cavern below PSNY.
- ***Further analysis is required to refine proposed conceptual alignment based on potential constraints imposed by Hudson Yards Development, and to develop pedestrian connections.***

5.1.6 Alt 7: Widening of Platforms 1 and 2

- Extension and widening of Platforms 1 and 2 and extension of Tracks 1-4 by removing the retaining wall under 31st Street and relocating Tracks 1, 2 and 3.
- New platforms would be able to accommodate 10-car plus locomotive train consists.
- Opportunity for significant improvements to pedestrian mobility and vertical circulation.
- The need to extend platforms and tracks eastward under 7th Avenue Subway and into the basement of the 11 Penn Plaza building, as in PSCE project, in order to provide desired platform length is reduced or eliminated.
- Significant relocation of columns and other vertical circulation components, especially on Platform 1. Minimal impact on the Diagonal Platform.
- Connections to both the NRT and the HRT are provided.

- Likely significant improvement of connections between Platforms 1 and 2 and the West End Concourse relative to those proposed as part of PSCE.
- Opportunities to provide new vertical access to 31st Street through the NY Terminal Service Plant (Amtrak's substation) or head house proposed as part of the PSNY Central Concourse Project.
- Require a substantial investment to remove the 31st Street retaining wall and would add little to no operational capacity. Therefore, widening of platforms was deemed undesirable and was not advanced since widening of platforms does not satisfy the goals and objectives of the project.

5.1.7 Alt 8: Widening of Platforms 1 and 2 by eliminating Track 3

- Extension and widening of Platforms 1 and 2 and extension of Tracks 1-4 by removing Track 3 and the retaining wall under 31st Street and relocating Track 1.
- New platforms would be able to accommodate 10-car plus locomotive train consists.
- Opportunity for significant improvements to pedestrian mobility and vertical circulation.
- Eastern extension underneath 7th Avenue is not required.
- Minimal relocation of columns and other vertical circulation components. Minimal impact on the Diagonal Platform.
- Connections to both the NRT and the HRT are provided.
- Likely significant improvement of connections between Platforms 1 and 2 and the West End Concourse relative to those proposed as part of PSCE.
- Opportunities to provide new vertical access to 31st Street through the NY Terminal Service Plant (Amtrak's substation) or head house proposed as part of the PSNY Central Concourse Project.
- Alt 8 is considerably less complex than Alt 7 given that existing vertical circulation to Platform 1 could remain in place throughout construction. Elimination of Track 3 would also make structural reconfigurations at platform and concourse levels less complex. However, Alt 7 would be preferred operationally given that the loss of one track required with Alt 8 would be highly undesirable, especially once HRT in place, which would allow for increased operations to PSNY.
- Require a substantial investment to remove the 31st Street retaining wall and would add little to no operational capacity. Therefore, widening of platforms was deemed undesirable and this alternative was not advanced since widening of platforms does not satisfy the goals and objectives of the project.

5.1.8 Alt 9: New 31st Street terminal east of 6th Avenue by eliminating Track 1

- Development of a new terminal under 31st Street and east of 6th Avenue by removing Track 1 and the retaining wall under 31st Street to create new terminal lead tracks below 31st Street.
- New terminal lead tracks run along south side of diagonal platform to provide connections to both the NRT and the HRT, similar to plans of the Penn Station Expansion Project.
- Would likely conflict with the currently envisioned Amtrak Penn Station Expansion Project and eliminate use of "E" Yard.
- Would represent a near-term loss of capacity through the elimination of Track 1.
- Additional connectivity to SSY in the future possible.
- Potential benefits for passenger distribution based on current travel patterns and NYCT subway capacity at Herald Square.
- Reduced connectivity to PSNY due to the location of the new terminal.
- Capacity this new Herald Square terminal would provide could not be delivered without the additional capacity provided by the Hudson River Tunnels.
- ***Requires additional study of property acquisition requirements, including development of access points to provide proper vertical and horizontal pedestrian circulation. Requires additional study of potential impacts to feasibility of Penn Station Expansion Project and required redesign.***

5.1.9 Alt 10: ARC feasibility review under new built environment

- Development of new tunnels from a redesigned HRT bellmouth to connect with the ARC track alignment. Connecting to the ARC lower level tracks is not feasible without redesign of ARC and connection would be limited to the ARC upper level.
- Redesigned HRT bellmouth and alignment can support advancing the upper level of ARC terminal with similar configuration and at the same location as originally proposed.
- Alternative requires development of HRT project.
- ***Further analysis is required to refine proposed conceptual alignment based on potential constraints imposed by Hudson Yards Development, and to determine extent to which vertical circulation, ventilation, and other elements of the ARC design could remain unchanged.***

5.1.10 Alt 11: Disconnect "U" and "M" Ladders from Tracks 1-4 and construct new "T" Ladder to widen and extend Platforms 1 and 2

- Extension and widening of Platforms 1 and 2 and connecting Tracks 1-4 to a new "T" Ladder south of the diagonal platform like that proposed to serve Amtrak proposed Penn Station Expansion platforms.
- Requires removal of the retaining wall under 31st Street and relocating Tracks 1, 2 and 3.
- New platforms would be able to accommodate 12-car train consists without extension under 7th Avenue subway.
- Pedestrian mobility on platforms and vertical circulation would be significantly improved.
- Significant relocation of columns and other vertical circulation components, especially on Platform 1. The Diagonal Platform will be demolished.
- Connections to both the NRT and the HRT are provided.
- Potential connection of Platforms 1 and 2 to the West End Concourse would be simplified.
- Opportunities to provide new vertical access to 31st Street through the NY Terminal Service Plant (Amtrak's substation) or head house proposed as part of the PSNY Central Concourse Project.
- ***Potential to refine design to only support 10-car plus locomotive train consists to limit impacts and better meet Amtrak design criteria.***

5.1.11 Alt 12: New "T" Ladder serving new platform on northern portion of Block 780

- Construction of a new tracks and platform on the north portion of Block 780 by removing the retaining wall under 31st Street and the Diagonal Platform and building a new "T" Ladder.
- Connections to both the NRT and the HRT are provided.
- Proposed alternative would limit property acquisition within Block 780 relative to the full Penn Station Expansion Project.
- Opportunities to provide new vertical access to 31st Street through the NY Terminal Service Plant (Amtrak's substation) or head house proposed as part of the PSNY Central Concourse project.

- Alternative builds off an Amtrak "T" Ladder arrangement not selected as preferred by Amtrak (Concepts 7 and 7A) under the Penn Station Expansion Project. This arrangement was not selected by Amtrak because it would only provide connections to the NRT from three new tracks and would have higher impact on "E" Yard. However, this arrangement was selected for the Alt 12 concept because it would allow a westbound train on the "T" Ladder to get closer to a merging conflict with the "U" Ladder (both trains operating to New Jersey) and closer to a crossing conflict with the "M" Ladder (the conflicting train operating from NJ). The Amtrak preferred "T" Ladder configuration pushes this conflict point farther east, which is less desirable operationally (in that it increases the length of the conflict zone).
- Alternative modifies Amtrak concept in terms of platform width and locations and, unlike Amtrak's preferred concept, it does not require eastern extension beyond 7th Avenue Subway to get full length platforms. Further study would be required to develop a modified Penn Station Expansion Project design that provides the same number of tracks and platforms.

5.1.12 Alt 13: Initial Phase of Amtrak Penn Station Expansion Project – New Platform

- Construction of a new tracks and platforms on the north portion of Block 780 by removing the retaining wall under 31st Street and the Diagonal Platform and building a new "T" Ladder.
- Connections to both the NRT and the HRT are provided.
- Preferred Alternative would require property acquisition within Block 780 and 806.
- Opportunities to provide new vertical access to 31st Street through the NY Terminal Service Plant (Amtrak's substation) or head house proposed as part of the PSNY Central Concourse Project.
- Based on the Amtrak Pre-Final Report, the preferred alternative (Concept 9) would provide the most operational benefits of any other concept, crucial connections to the NRT (via the "T" Ladder) for five new tracks, and preserve up to 300 ft. more of "E" Yard. However, the Amtrak preferred concept requires extension to the east of 7th Avenue and impacts Block 806.
- Allows for future full build out of Amtrak's preferred alternative for Penn Station Expansion Project.

5.1.13 Alt 14: Disconnect "U" and "M" Ladders from Tracks 1-4 and construct new "T" Ladder to extend Platforms 1 and 2 West

- Extension of Platforms 1 and 2 by constructing a new "T" Ladder south of the diagonal platform as proposed under the Penn Station Expansion Project by Amtrak.

- New platforms would be able to accommodate 12-car train consists without extension under 7th Avenue subway.
- The Diagonal Platform will be demolished. Considerable impact to "E" Yard.
- Connections to both the NRT and the HRT are provided.
- Does not require any modification of existing columns or vertical circulation on Platforms 1 and 2.
- Potential connection of Platforms 1 and 2 to the West End Concourse would be simplified.

5.1.14 Alt 15: PSCE 30% Design – Eastern and western extension of Tracks 1-4

- Eastern and western extension of Platforms 1 and 2 and Tracks 1-4 to accommodate 11-car train consists (ten cars plus a locomotive).
- Modifications to the "U" and "M" Ladders required. Minimal impact to The Diagonal Platform and "E" Yard.
- Underpinning of 7th Avenue Subway and systems relocations required. Significant impact to 11 Penn Plaza Building.
- Connections to both the NRT and the HRT are provided.
- Provides connectivity to 7th Avenue Subway and West End Concourse; but, connections are constrained.

5.2 Preliminary Infrastructure Alternatives Evaluation

The infrastructure alternatives evaluated generally fall into three distinct categories: those that could add capacity prior to the completion of the Hudson River Tunnels (HRT) (Alt 5, 7, 8 and 15), those that would require the new HRT infrastructure before any benefits can be achieved (Alt 1, 2, 3, 4, 6 and 10) and those that could provide benefits both in the near term and after the completion of the HRT project (Alt 9, 11, 12, 13 and 14). The preliminary analysis of the alternatives considered revealed the following:

- The concepts envisioned at the outset of the project (Alt 1, 2 and 5), namely provision of new tracks and a platform below 31st Street and extension past 6th Avenue are infeasible given constrained space within 31st Street and the elevation of the NYCT 6th Avenue Subway.
- There are feasible alternatives (Alts 6 and 10) to build new tracks and platforms that utilize the additional trans-Hudson capacity to be provided by the HRT. These alternatives represent longer-term options requiring significant capital investment and are therefore considered as only partially meeting the goals and objectives of this project. Advancement of these alternatives is also outside the scope of this project.

Nevertheless, these longer-term solutions are compatible with the alternatives selected to move forward and could be part of a future study to add capacity to PSNY as an incremental addition after HRT is in place or as part of the Gateway Expansion Program.

- There are feasible alternatives (Alts 7, 8, and 11) to widen and lengthen Platforms 1 and 2. While widening platforms could allow for significantly improved vertical circulation and customer experience, they would require a substantial investment to remove the 31st Street retaining wall and undertake structural modifications required. Each of these alternatives could include lengthened platforms which would deliver some operational benefit by providing the flexibility for longer trainset consists on more platforms at PSNY. Moreover, if coupled with longer-term alternatives to add platforms and tracks (Alts 6 and 10) once the HRT are completed, these alternatives could provide for improved NJ TRANSIT operations at PSNY. However, these alternatives would provide little to no additional operational capacity in the near-term as compared to alternatives that would just more simply extend Platforms 1 and 2 since vertical circulation does not constrain operations in these platforms.

- There are feasible alternatives (Alt 14 and Alt 15) to lengthen Platforms 1 and 2 without the widening that would require elimination of the 31st Street retaining wall. These alternatives would deliver some operational benefit by providing flexibility to handle longer trainset consists on more platforms at PSNY and would add seat capacity to help address congestion. Alt 14 and 15 would not significantly address platform congestion but could allow for improved vertical circulation capacity with connections to the West End Concourse. Study and evaluation of tradeoffs between these alternatives in terms of West End Concourse connectivity, underpinning requirements of the 7th Avenue subway, subway connectivity, and relocation of systems infrastructure is recommended and would be part of the next phase of this Task.

- There are feasible alternatives (Alts 12 and 13) to add near-term capacity by building two tracks and one platform south of existing Track 1 and requiring limited acquisition of real estate along the south side of 31st Street. These alternatives could potentially represent an initial phase of the Amtrak envisioned Penn Station Expansion Project or could be paired with other alternatives that would use a potential HRT bellmouth to provide the additional platform capacity required long term once the HRT project is completed (Alts 6 and 10). Concepts to widen Platforms 1 and 2 (Alts 7, 8, and 11) would make it infeasible to add the new platform and tracks without significant impact to St. John the Baptist Church.

- Finally, a feasible alternative (Alt 9) was identified to add significant new capacity near Herald Square that would not conflict with the HRT project and could be served by the existing NRT. There are several issues with this alternative that prevent it from being implementable in the near term. For example, this project would conflict with the currently-envisioned Amtrak Penn Station Expansion Project, would represent a temporary loss of capacity through the elimination of Track 1, and would add capacity distant from existing PSNY which would result in operational and customer challenges. Furthermore, the capacity this new 5th Avenue terminal would provide could not be

delivered without the additional capacity provided by the HRT. As such, this alternative only partially satisfies this project's goals and objectives.

This preliminary evaluation has identified five alternatives that warrant additional evaluation. They were further categorized in three groups as follow:

- *Longer and wider Platforms 1 and 2 that deliver some operational benefit by providing flexibility for handling longer trainset consists on more platforms at PSNY (Alt 11):* Wider platforms would provide an improved passenger environment at platform level and could allow for improved vertical circulation. Separating Tracks 1-4 from the "U" and "M" Ladders while providing connectivity to both the North River Tunnels and the future HRT would also provide additional operational benefits once the HRT are completed. While eliminating the issues associated with extending under the 7th Avenue Subway, this alternative would eliminate future use of "E" Yard for passenger equipment and would require modifications to the Penn Station Expansion Project conceptual design.

- *Longer platforms that deliver some operational benefit by providing flexibility for longer trainset consists on more platforms at PSNY (Alt 14 and 15):* This foregoes widening of platforms to reduce costs and impacts. Separating Tracks 1-4 from the "U" and "M" Ladders could provide additional operational benefits once the HRT are completed.

    - Alt 14 would not require extending below the 7th Avenue Subway but would eliminate use of "E" Yard for passenger equipment and would require modifications to the Penn Station Expansion Project conceptual design.

    - Alt 15, PSCE project advanced to 30% design, would provide connectivity to 7th Avenue Subway and West End Concourse; but, connections are constrained, require underpinning 7th Avenue Subway, systems relocations, and real estate impacts.

- *Two additional tracks and an island platform south of existing Track 1 (Alt 12 and 13) that deliver additional meaningful platform capacity at PSNY, provide an opportunity for new vertical and horizontal pedestrian circulation improvements and connect to both the existing NRT and the planned HRT:*

    - Alt 12 would limit real estate requirements but requires demolition of the 31st Street retaining wall. To meet long term capacity needs with HRT in place, this alternative would require modifications to the Penn Station Expansion Project conceptual design or could be combined with Alt 6 or 10.

    - Alt 13 would avoid any redesign of the Penn Station Expansion Project as it proposes to advance a first phase of the currently proposed design, but it would have a larger impact on the buildings South of 31st Street and on the West side of Block 806.

Table 2 on the following page summarizes the description, characteristics and evaluation of the alternatives proposed as well as the recommendation resulting from this effort.

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Infrastructure Alternatives Evaluation Summary

Alternative	Requires Removal of 31st Street Retaining Wall	Requires HRT	Compatibility with Penn Station Expansion	Spatial Feasibility	Design Criteria Compatibility	Project Goals & Objectives	Comments		Recommendation
Alt 1 & 2: New platforms below Tracks 1-4 connecting via south side of the Diagonal Platform	No	Yes	No	Fail	Fail	Fail	Inadequate clearance at acceptable profile grade. Requires HRT. No connection to NRT.		Do Not Advance.
Alt 3: New deep-level terminal below PSNY connecting to the bellmouth	No	Yes	Yes	Fail	Fail	Fail	Use of HRT bellmouth operationally unacceptable.		Do Not Advance.
Alt 4: New deep-level terminal under 30th Street connecting to the bellmouth	No	Yes	Yes	Fail	Fail	Fail	Use of HRT bellmouth operationally unacceptable. 30th Street too far removed from PSNY.		Do Not Advance.
Alt 5: Extension of Tracks 1 and 2 below 6th Avenue	No	No	Yes	Fail	Fail	Fail	Inadequate clearance at acceptable profile grade under 6th Avenue Subway.		Do Not Advance.
Alt 6: New deep-level terminal below PSNY with revised bellmouth design	No	Yes	Yes	Pass	Pass	Marginal	Requires HRT. Potential alternative to Penn Station Expansion Project. Could be combined with Alts 7 or 8.		Future Study.
Alt 7: Widening of Platforms 1 and 2	Yes	No	Yes*	Pass	Pass	Fail	Existing vertical circulation does not constrain operations. Alt 11 preferred.		Do Not Advance.
Alt 8: Widening of Platforms 1 and 2 by eliminating Track 3	Yes	No	Yes*	Pass	Pass	Fail	Loss of operational capacity potential when HRT online.		Do Not Advance.
Alt 9: New 31st Street terminal east of 6th Avenue by eliminating Track 1	Yes	No	No	Pass	Marginal	Marginal	May require exceeding design criteria to bring terminal further west. Major project that would require HRT to deliver full capacity.		Future Study.
Alt 10: ARC feasibility review under new built environment	No	Yes	Yes	Pass	Pass	Marginal	Requires HRT. Possible to leverage past work on design and property acquisition.		Future Study.
Alt 11: Disconnect “U” and “M” Ladders from Tracks 1-4 and construct new “T” Ladder to widen and extend Platforms 1 and 2	Yes	No	Yes*	Pass	Pass	Pass	Longer and wider platforms with better West End Concourse connections. Could be paired with alts 6 and 10. Comparable with Alt 14 and Alt 15.		Advance this or Alt 14.
Alt 12: New “T” Ladder serving new platform on northern portion of Block 780	Yes	No	Yes*	Pass	Pass	Pass	Modifies Amtrak concept. Could be paired with alts 6 and 10. Comparable with Alt 13.		Advance this or Alt 13.
Alt 13: Initial Phase of Amtrak Penn Station Expansion Project – New Platform	Yes	No	Yes	Pass	Pass	Pass	Allows for future full build out of Amtrak concept. Could be paired with alts 6 and 10. Comparable with Alt 12.		Advance this or Alt 12.
Alt 14: Disconnect “U” and “M” Ladders from Tracks 1-4 and construct new “T” Ladder to extend Platforms 1 and 2	Yes	No	Yes*	Pass	Pass	Pass	Longer platforms with better West End Concourse connections. Could be paired with future terminal expansion alts 6 and 10. Comparable with Alt 15		Advance this or Alt 15.
Alt 15: PSCE 30% Design - Eastern and western extension of Tracks 1-4 **	Yes	No	Yes	Pass	Pass	Pass	Longer tracks and platforms to accommodate 10-car trains. 30% design has been completed. Comparable with Alt 14.		Advance this or Alt 14.

** Alternative is compatible with Penn Expansion Project but would require modifications to the currently-proposed design.*

*** This alternative has not been developed as part of the PCIP effort and it would be advanced for comparison purposes only.*

Source: Developed for the PCIP Study.

Table 2: Preliminary Infrastructure Alternatives Evaluation Summary.

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5.3 Preliminary Operations Alternatives Description

Operational alternatives were developed in coordination with NJ TRANSIT through discussions of existing operational practices and constraints. These discussions included observations of routine practices, common challenges and problems related to reliability and station crowding, and incident management. Two short term and one long term operationally-oriented alternatives were proposed for further analysis and evaluation as a result of this coordination.

- Alt OP1 entails reducing the NJ TRANSIT minimum revenue-to-revenue turn time from 22 minutes to 18 minutes and reconfiguring all scheduled NJ TRANSIT turns assuming train equipment can be turned interchangeably. The minimum revenue-to-revenue turn time is a reduction of four minutes from the current NJ TRANSIT standard and would require permanent increases in operating personnel, including platform supervision and relief operating crews. No changes to the dwell times associated with movements to and from Sunnyside Yard are contemplated as part of the operationally-oriented alternatives.

  If there are equipment imbalance issues identified as part of any of the operationally-oriented alternatives, eastbound or westbound trips would be added as necessary while trying to use existing slots in the NRT. The Study Team verified that 24 TPH (Amtrak/NJ TRANSIT combined) is operated in the NRT (excluding Empire Corridor trains from the count), consistent with existing "X" Tracks constraints. The Study Team generated new track occupancy charts to reflect this operation. The option for maintaining one full length track (Track 7-12) open as an emergency track for out-of-slot trains for the duration was maintained. This will improve reliability by allowing one station track to remain unused during normal operations which would provide recoverability in the event of train delays/bunching/out-of-slot Amtrak Long Distance trains.

- Alt OP2 entails revising the NJ TRANSIT minimum revenue-to-revenue turn time to 18 minutes and reconfiguring all scheduled NJ TRANSIT turns as previously indicated. In addition, this alternative includes increasing the NRT eastbound volume from 24 TPH to 26 TPH with the restoration of the Track 3X move to 30 MPH and implementation of a new Track 1X move at 30 MPH through the installation of higher speed turnouts at and near the NRT portal. In this scenario, keeping one track (Track 7-12) open for recoverability purposes is not prioritized since the main goal was to assess if increasing the NRT eastbound volume to 26 TPH is feasible under the specified conditions.

- Alt OP3, which is the long-term alternative, also entails revising the NJ TRANSIT minimum revenue-to-revenue turn time to 18 minutes and reconfiguring all scheduled NJ TRANSIT turns as previously indicated. However, this alternative assumes that the new HRT is in service with 3-minute headways on each of the two inbound tracks and therefore considers a total eastbound volume of 40 TPH. This alternative also assumes that the 1X/3X trackwork improvements were implemented. If saturation is reached before the 40 TPH volume, the analysis would back off on the number of trains and report the maximum supportable volume. Alt OP3 would be expected to provide additional capacity and may have a positive impact on reliability as well.

5.4 Preliminary Operations Alternatives Evaluation

Table 3 summarizes the operationally-oriented alternatives proposed. Evaluation of these operational alternatives includes the work required to deliver the "X" Tracks improvements. No additional engineering design beyond the "X" Tracks improvements is included as part of operational alternatives.

Alternative	Spatial Feasibility	Design Criteria Compatibility	Project Goals & Objectives	Comments	Recommendation
Alt OP1: Rev-to-Rev turn time of 18 min.	Pass	Pass	Pass	Reliability improvements.	Advance.
Alt OP2: Rev-to-Rev turn time of 18 minute with "X" Tracks improvements.	Pass	Pass	Pass	Capacity and potential reliability improvements.	Advance.
Alt OP3: Rev-to-Rev turn time of 18 minute with X Tracks improvements and HRT.	Pass	Pass	Pass	Capacity and potential reliability improvements.	Advance.

Source: Developed for the PCIP Study.

Table 3: Operationally-Oriented Alternatives Proposed.

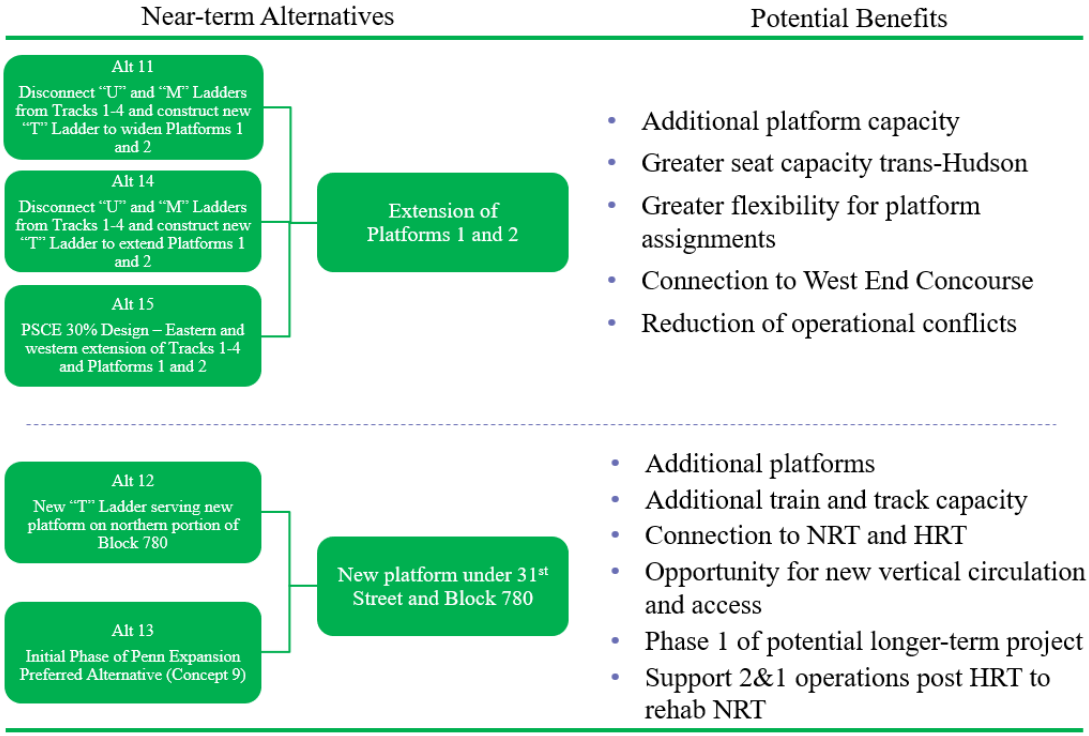
The concept of preloading platforms was discussed with NJ TRANSIT as a potential approach to reduce concourse level congestion and to reduce dwell time. However, it was decided that preloading platforms would not be feasible given current dynamic assignment of tracks controlled by Amtrak, platform sizes, congestion, and vertical circulation capacity. In addition, track assignments for NJ TRANSIT trains are often changed at the last minute by PSCC dispatchers (due to other trains with mechanical issues, passengers in need of assistance, etc.) so preloading platforms could result in many hundreds of customers needing to switch platforms to board their train.

At first glance, an obvious solution to this would be to have a terminal track assignment plan (also known as a terminal operating plan) where track assignments are predictable and known in advance by regular NJ TRANSIT passengers. LIRR Penn Station trains operate this way. Amtrak has traditionally opposed such a terminal track assignment plan for the shared Amtrak/NJ TRANSIT tracks because of greater train arrival and departure variability than that experienced by the LIRR. This reflects the complex dispatching on the NEC between Washington and Boston as well as the freight railroad interactions of all long distance and many Empire Corridor trains, which results in these trains arriving up to 40 minutes early (due to recovery time in their schedules) or many hours late. Such variability requires dynamic track assignments as standard operating practice.

5.5 Alternatives Selection

This preliminary review has identified many infrastructure alternatives (Alt 11, 12, 13, 14 and 15) and operational alternatives (Alt OP1, OP2 and OP3) that are feasible, and that satisfy all or most of the project goals and objectives. This section provides a comparison of the feasible infrastructure alternatives based on a combination of high-level and qualitative metrics to identify which infrastructure alternatives could be advanced to Phase 2 of this Study.

The preliminary evaluation and screening revealed that there are five near-term feasible infrastructure alternatives, which can be grouped based on the type of improvement proposed as shown in Figure 11.



Source: Developed for the PCIP Study.

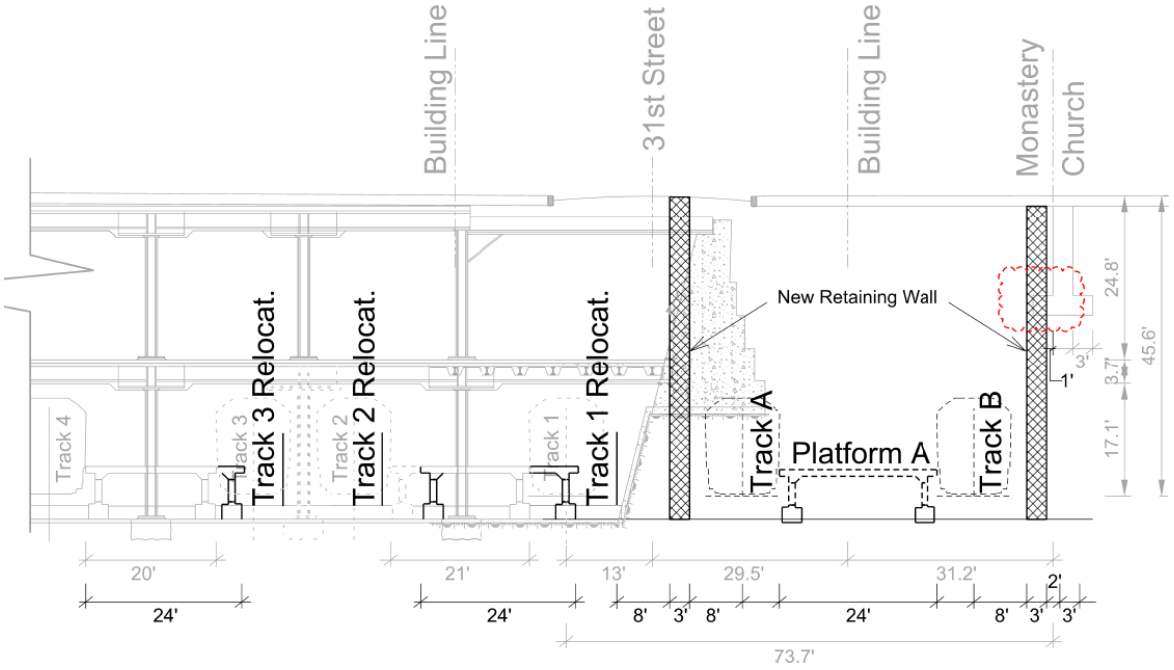
Figure 11: Grouping of Feasible Near-Term Alternatives and Their Potential Benefits.

Group 1 represents those alternatives that extend Platforms 1 and 2 to provide operational flexibility and seat capacity. Group 2 represents those alternatives that build a new platform and tracks underneath 31st Street and Block 780 to provide additional train capacity as well.

The two groups of alternatives provide benefits that are complementary. As such, a potential approach to incremental investment could include implementation of one alternative from each group. Further, the decision to advance an alternative from either group, or one from each, needs to consider how such an approach would complement the operational alternatives considered. Therefore, one of the first parameters that needs to be considered when evaluating the five feasible near-term alternatives and selecting those that should be advanced to Phase 2 is the compatibility between alternatives.

The obvious concern regarding compatibility would be for Alt 11 in Group 1, which includes widening of Platforms 1 and 2 through "relocation and redesign" of the retaining wall to just outside the south building line of 31st Street, with the Group 2 alternatives that propose a new island platform and tracks partially within 31st Street. As such, a conceptual space allocation was undertaken to determine if Platforms 1 and 2 could be widened without precluding the provision of new platform, or requiring unacceptable impacts, in particular, impacts to St. John the Baptist Church.

Figure 12 below shows a conceptual north-south cross section with Platforms 1 and 2 increased to the minimum desirable width of 24 ft and a new platform of the same width. The cross section was based on the information gathered for the PCIP Study under Task 1. Detailed information was not available on the church but based on professional judgement it is assumed that the church is founded on rock with footings that extend 3 ft beyond the church building line as shown. Given an estimated retaining wall width of 3 ft, the new retaining wall would lie adjacent to the church building line which would impact the church's foundation as shown on the mentioned figure. Ideally, there would be 2 ft of construction between the proposed retaining wall and the church footing requiring approximately an additional total of 5 ft. Therefore, the conclusion of this space allocation analysis is that widening Platforms 1 and 2 is considered incompatible with adding a new platform.



Source: Developed for the PCIP Study based on PSCE 30% Preliminary Engineering Design Drawings. DWG No. ST-119.

Figure 12: Alt 11 North-South Cross Section Evaluating Platform Widening Compatibility.

To mitigate the compatibility issues, a modified version of Alt 11 that would only widen Platform 1 and thereby eliminate the previously suggested 4 ft widening of Platform 2, was also considered. This option could potentially be feasible without impacting the historic portion of the church and could be studied further during more detailed project development should PCIP alternatives advance to more detailed design development.

Table 4 summarizes the compatibility analysis of the five infrastructure alternatives. Note that alternatives within a group are mutually exclusive; it is not feasible to implement two alternatives from the same group as they both propose different approaches to realize a similar concept.

Compatibility between Near-Term Alternatives

	Compatible With				
Near-term Alternatives	Alt 11	Alt 14	Alt 15	Alt 12	Alt 13
Alt 11 Disconnect "U" and "M" Ladders from Tracks 1-4 and construct new "T" Ladder to widen and extend Platforms 1 and 2		🔴	🔴	🔴	🔴
Alt 14* Disconnect "U" and "M" Ladders from Tracks 1-4 and construct new "T" Ladder to extend Platforms 1 and 2			🔴	🟡	🟡
Alt 15 PSCE 30% Design – Eastern and western extension of Tracks 1-4				🟢	🟢
Alt 12 New "T" Ladder serving new platform on northern portion of Block 780					🔴
Alt 13 Initial Phase of Amtrak Penn Station Expansion Project – New Platform					

Legend		
🔴 Incompatible Alternatives	🟡 Potentially Compatible Alternatives*	🟢 Compatible Alternatives

**Compatibility of Alt 14 with Alt 12 or Alt 13 could be further studied. Proposed "T" Ladder could be modified to potentially improve compatibility.*

Source: Developed for the PCIP Study.

Table 4: Compatibility between Near-Term Preliminary Alternatives.

As shown in Table 4, Alt 15 and Alt 14 are compatible with Alt 12 and 13. There is no conflict between Alt 15 and the concepts for a new platform; these projects have very little direct overlap. However, the preliminary "T" Ladder arrangements developed for Alternatives 12 and 14 were developed independently; therefore, they are not directly compatible. A yellow indication was provided because the "T" Ladder arrangement could be revisited to improve

compatibility for Alt 14. The diagram also shows that Alt 11 is not compatible with any of the other alternatives considered as already discussed.

In addition to space constraints, the widening of Platforms 1 and 2 proposed on Alt 11 introduces significant additional constructability and phasing challenges and would result in increased impacts and costs relative to the platform extensions proposed in Alts 14 and 15. More importantly, widening the platforms as an independent initiative was determined through the operational review not to provide increased train or seat capacity, the primary goal of this Project, which is why Alts 7 and 8 were eliminated. Alt 11 would improve the passenger experience and could potentially support the concept of preloading platforms; however, absent an Amtrak terminal operating plan, preloading platforms is not feasible given current dynamic assignment of tracks by Amtrak dispatchers as previously discussed in Section 5.4.

Based on the results of this analysis, widening of platforms 1 and 2 (Alt 11) was eliminated from further consideration due to its incompatibility with the other near-term alternatives and the Penn Station Expansion Project as currently designed, the higher impact, risk, and cost associated with the removal of the retaining wall, and the fact that no additional train or seat capacity would be provided. **Infrastructure alternatives Alt 12, 13, 14 and 15 and operational alternatives Alt OP1 and OP2, which are compatible with all infrastructure alternatives, were recommended to be moved forward.** It is important to note that Alt 14, which is being advanced, does extend and widen the western portion of the platform and provide connections to the West End Concourse. In combination with the planned extension of the Central Concourse, this alternative would greatly improve platform space and vertical circulation capacity to address congestion on Platforms 1 and 2.

Alt OP3, while originally recommended to be advanced, was not further developed or evaluated as it is a long-term alternative and therefore falls outside of the goals and objectives of this Project. In addition, Alt OP3 would require network simulations which were not authorized and hence it is expected that this alternative would be studied in detail as part of a future Project.

The alternatives that are moved forward to Phase 2 were further developed and a comprehensive evaluation performed. Alt 12 and 14 were developed in combination as one single alternative (but retaining the "Alt 12 + Alt 14" designation") to ensure compatibility. Alt 13 and 15 in combination were also advanced, but for comparison purposes only. Finally, Phase 2 also analyzed the effectiveness and impact of implementing several near-term alternatives in combination as the preliminary study undertaken to date indicates that the groups of near-term alternatives considered are highly related.

Given the highly conceptual nature of the PCIP Study and the fact that development and evaluation of alternatives is preliminary at this stage, this additional evaluation and selection of alternatives was based on professional judgment on several high-level and qualitative metrics and on input provided by NJ TRANSIT Department of Capital Planning and Programs and Rail Operations in the three meetings held to discuss the development of alternatives (Meeting #4 on 2018-10-09, Meeting #5 on 2018-11-09, and Meeting #6 on 2018-12-17). Table 5 at the end of this section provides a summary of the five feasible near-term infrastructure alternatives.

Feasible Near-Term Infrastructure Alternatives Preliminary Evaluation Summary

Near-term Alternatives	Requires HRT	Requires Removal of Retaining Wall	Requires Underpinning 7th Avenue Subway	Requires New "T" Ladder and Removal of Diagonal Platform	Compatible with Penn Station Expansion Project	Compatible with other Proposed Near-Term Infrastructure Improvements	Advance to Phase 2 Evaluation
Alt 11 Disconnect "U" and "M" Ladders from Tracks 1-4 and construct new "T" Ladder to widen and extend Platforms 1 and 2	No	Yes	No	Yes	No	No	No
Alt 14 Disconnect "U" and "M" Ladders from Tracks 1-4 and construct new "T" Ladder to extend Platforms 1 and 2	No	No	No	Yes	Partially	Yes	Yes
Alt 15* PSCE 30% Design – Eastern and western extension of Tracks 1-4	No	No	Yes	No	Yes	Yes	Yes
Alt 12 New "T" Ladder serving new platform on northern portion of Block 780	No	Yes	Yes	Yes	Partially	Yes	Yes
Alt 13* Initial Phase of Amtrak Penn Station Expansion Project – New Platform	No	Partial Removal	Yes	Yes	Yes	Yes	Yes

** This alternative has not been developed as part of the PCIP effort and it would be advanced for comparison purposes only.*
Source: Developed for the PCIP Study.

Table 5: Feasible Near-Term Infrastructure Alternatives Preliminary Evaluation Summary.

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6 Development of Selected Infrastructure Alternatives (Task 4A)

6.1 Development Approach

Given the highly conceptual nature of the PCIP Study, development and evaluation of alternatives is preliminary at this stage. In keeping with the exploratory nature of the requested work, the level of detail developed for each alternative is limited but was sufficient to estimate the potential passenger and train capacity benefits, to define the general infrastructure configuration, and to confirm feasibility of construction. The detail developed was also sufficient to communicate the proposed alternatives to NJ TRANSIT management, to allow for an assessment of operational feasibility and potential environmental and property impacts, to support development of comparative capital cost estimates and construction schedules, and ultimately to support a NJ TRANSIT decision regarding which alternative or group of alternatives should be advanced. It is expected that the next stage of design for any of these alternatives would involve further development of structural, track, architectural, fire and life safety systems, and other systems elements, as well as further constructability, cost, and schedule reviews.

The preliminary development and evaluation of alternatives determined that the four infrastructure alternatives selected to move forward to Phase 2 were:

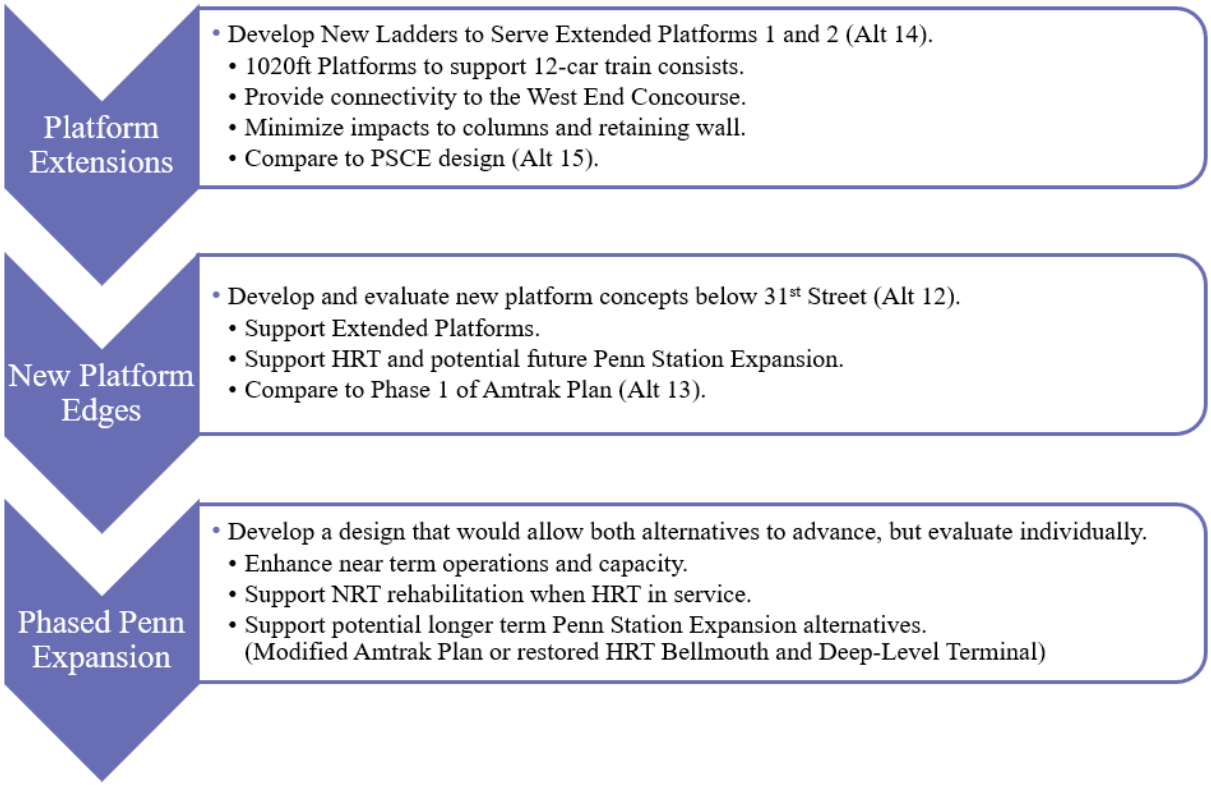
- Two infrastructure alternatives to build a new platform south of Track 1 that are compatible with plans for the new HRTs:
  - Build new platform and two tracks under 31st Street and the northernmost part of Block 780 (Alt 12), and
  - Build the northernmost platform and two tracks of the Amtrak Penn Station Expansion (PSE) concept (Alt 13). This would be considered the initial phase of PSE.
- Two infrastructure alternatives to extend Tracks 1-4 and Platforms 1 and 2 to support longer trains that are compatible with plans for the new HRTs:
  - Westward extension of Platforms 1 and 2 (Alt 14), and
  - PSCE - Eastern and western extension of Tracks 1-4 (Alt 15). Previously developed to 30% under the Penn Station Capacity Enhancement (PSCE) Project.

Out of these four alternatives, Alt 12 and 14 were developed as part of this Project and Alt 13 and 15 were advanced for comparison purposes only. Therefore, this section focuses on the approach followed to develop infrastructure Alt 12 and 14.

As previously stated, while conceptually it would be feasible to move forward both Alt 12 and 14, the track alignments of these two alternatives were developed independently and therefore the preliminary proposed “T” Ladder arrangements as well as some sections of the track layout

are not directly compatible. Since developing alternatives that would support a practical incremental investment plan to increase train capacity at PSNY is one of the main objectives of this Project, it was important to develop a design in which both concepts (Westward extension of Platforms 1 and 2 and New Platform under 31st Street and Block 780) are compatible and could be moved forward. Therefore, it was determined and agreed with NJ TRANSIT that both alternatives would be combined and developed as one design. Once the conceptual design was completed, the two alternatives would be evaluated separately as they each have independent value and they would be compared to Alt 13 and 15 based on the criteria developed as part of Task 3. Figure 13 summarizes this approach which was followed to further develop and evaluate the two mentioned infrastructure alternatives.

From a track perspective, based on the described approach, the preliminary proposed alignments were revised to ensure compatibility and to optimize the value provided when both alternatives are advanced. To accomplish this, four different feasible track layout options were developed (Options 1, 2, 3 and 4) as described in Section 6.3. Track alignment plans and schematics for these four options considered are included in in the Supplementary Drawings section in Appendix A. Option 4, which minimizes structural impacts while providing good parallel move capability and connections to both NRT and HRT, was determined to be the preferred track alignment.



Source: Developed for the PCIP Study.

Figure 13: Approach to Development of Selected Infrastructure Alternatives.

The conceptual track design proposed in Option 4 was then further developed and significant revisions were made to properly incorporate additional architectural, structural, track and geotechnical considerations and to address preliminary comments received from NJ TRANSIT. The track drawing plan as well as the track schematic for the final conceptual version are included in Appendix A (Drawings TK-011, TK-012 and TK-013). Furthermore, to support the independent evaluation of the two original alternatives (Alt 12 and 14) and to provide NJ TRANSIT with the option, if desired, of advancing just one of them, Alt 12 and 14 were separated and the respective conceptual design drawings are also included in Appendix A. From a track perspective, minor revisions were made on the separated designs to provide additional track connections (for example to "E" Yard) that became feasible when considering the alternatives individually. However, no changes were made to the alignment of the proposed ladders or platform tracks. The small modifications made are further explained and justified in each alternative specific report section. Finally, it is important to note that while the proposed track alignments support advancing both alternatives, a more optimal track layout could be developed if only one of the two alternatives was to be advanced and precluding the other alternative was acceptable. If this was the case, it is anticipated that the proposed track layout would be further studied and revised as part of the next phase of this Project or under a separate future Study.

6.2 Track Design Criteria Basis

Track alignments for the different track layout options were developed based on the design criteria established by Amtrak Engineering Specification No. 63. While considerable efforts were made to comply with Spec No. 63, due to the existing track layout in PSNY and other existing spatial constraints, specific desired and required values established set out in that standard were relaxed. The following project specific design criteria were used for the track design of the selected alternatives described in the following sections of this report. When appropriate, the relevant chapter number for Specification No. 63 is noted in parenthesis after each criterion below.

- Clearances along proposed alignments must meet minimum roadway clearances prescribed in Amtrak Standard Track Plan AM 70050 (4.2.2). Minimum clearance to permanent structures inside of buildings such as Penn Station, is 8 ft. Minimum clearance used was reduced to 7 ft plus one-inch allowance per degree of curvature for new tracks. This standard was previously agreed to by Amtrak in our recent design of track improvements at Chicago Union Station, a similarly constrained environment. Final design would have to justify any relaxation of the requirements of Spec No. 63 with site specific design criteria exception requests.
- Existing clearances on existing tracks that are proposed for realignment would be maintained or exceeded.
- The minimum radius of curvature used was greater than or equal to the minimum of 459.28 ft (maximum curvature 12°30') permitted in Spec No. 63 (4.3.4).

- The tangent distance between reverse curves or turnouts of the same hand was designed to be no less than 68 ft, which is the distance from the front truck to the rear truck of an 85-foot passenger rail vehicle.
- Curves were designed to be whole numbers of degrees, minutes and seconds (4.3.6).
- Curvature within the limits of high level passenger platforms were avoided where practicable, and in all cases curvature within platforms was designed to be greater than the minimum allowed of 1°40’ (Amtrak Standard Track Plan AM 70050). Minimum curvature on station tracks within the platform limits was increased to 3°00’ to limit the platform gap to less than 13 inches, which is the maximum allowed by NJ TRANSIT Guidelines and Standards Manual.
- No superelevation and or spirals were included in design as appropriate given slow speed geometry.
- The design speed considered was 15 mph. However, it is anticipated that trains would run at lower speeds (i.e. 10 mph) throughout some sections of the station.
- The minimum track centerline to track centerline spacing on tangent track was designed to be no less than 14 ft (4.11.2). The minimum spacing used was reduced to 13 ft to match existing track spacing where required.
- No grades exceeding 2.5% compensated (5.1.2) were used.
- The maximum allowable rate of change for vertical curves was less than 1.0% per 100 ft of length (5.5.1.3).
- Turnouts were not be located on vertical curves (5.5.3).
- No. 8 conventional turnouts with RMB frog were used where the use of a No. 10 or greater size turnout was not practical (7.2.2.5).
- The minimum distance between the end of a horizontal curve and the point of switch of a turnout was no less than 4 ft.
- Turnout, double slip switches and crossing geometry were developed in accordance with Section 7, 8 and 9 respectively.

6.3 Track Alignment Options Development

Four alternative conceptual track layout options were developed (Options 1, 2, 3 and 4) that supported extending Platforms 1 and 2 (Alt 14) westward and building a new platform under 31st Street and Block 780 (Alt 12). Track alignment plans and schematics for these four options considered are included in the Supplementary Drawings section in Appendix A. The following items are common in the four options considered:

- New "T" and "R" Ladders connecting existing Tracks 1-3 and the new A and B Tracks to both the NRT, via Tracks 1X and 2X, and to the future HRT, via Track 1A.
- Westward extension of Platforms 1 and 2 to 1020 ft to support 12-car train consists and new 1020-foot long Platform A under 31st Street and the north section of Block 780. The location of this platform avoids impacts to existing buildings on Block 806.
- Option to develop, as part of the Future Penn Station Expansion Project, three additional platforms in Block 780 to avoid impacts to existing buildings on Block 806. Proposed Tracks C-H serving these three platforms would only be connected to the HRT, via new "S" and "V" Ladders connecting to Tracks 1A and 2A.
- The importance of connections to "E" Yard and the storage capacity that it provides are not significant as the usable track lengths would limit the storage to Maintenance of Way (MOW) equipment.

Option 1 proposed a configuration of the "T" and "R" Ladders with "scissor" crossovers and No. 8 double slip switches. The proposed "T" Ladder would be connected to a new No. 8 double slip switch, which would replace the existing turnout (switch No. 87) that connects Tracks 2X and 3X. The "R" Ladder would connect to Track 1X. While the location of these proposed connections would minimize impact and conflicts on the "U" and "M" Ladders, the "T" Ladder proposed would require the relocation of an entire line of columns (23 columns) that support the existing 9th Avenue Overpass. In Option 1, the track alignment for the proposed future Penn Station Expansion uses No. 10 turnouts and No. 10 double slip switches. Option 2 proposed a similar conceptual track layout to Option 1, but it modified the "T" Ladder to connect it to the "M" Ladder to avoid the impact on the columns supporting the 9th Avenue Overpass. While this modification reduced the overall structural impacts, Option 1 was preferred from an operational point of view as Option 2 would increase traffic in the existing "M" Ladder and potentially create a choke point as all trains servicing Tracks 2, 3 and 4 would have to pass through the "M" Ladder.

Option 3 proposed a "T" and "R" Ladder design based on the existing "U" and "M" Ladders to provide an option that would better support parallel moves. Inbound and outbound parallel movements are critical to support high volume train operations and currently the existing "U" and "M" ladder tracks can support an inbound move concurrently with an outbound move from the next higher station track. The "T" Ladder was connected to Tracks 2X and 3X with a new No. 8 double slip switch, which would replace the existing turnout (switch No. 87), similar to Option 1. Option 4 proposed a similar conceptual track layout to Option 3, which greatly supports parallel moves, but it modified the "T" Ladder to connect it to the "M" Ladder to avoid the impact on the columns supporting the 9th Avenue Overpass. While this modification reduced the overall structural impact, Option 4 created a choke point on the "M" Ladder as Tracks 2, 3 and 4 would feed through a single point. While this is operationally less desirable, it was not considered to be an unacceptable issue or constraint.

The track layout for the four options proposed was reviewed from an operational, structural and track perspective and in coordination with NJ TRANSIT, it was determined that Options 1 and

2 would not be advanced as they presented several choke points and, unlike the existing "U" and "M" Ladders in PSNY, they lacked the capability to support desired parallel moves. As examples of this, Access to Tracks 1, A, and B would pass through a single choke point in Ladder "R" or Tracks C, D, and E would pass through a single choke point in Ladder "S". On the other hand, Option 3 would require the relocation of approximately 28 columns that support the 9th Avenue Overpass. Based on the close spacing of the existing PSNY track columns, it is expected that the existing framing supporting the station ceiling and the street above is heavily loaded. As such, from a constructability point of view, the relocation of these columns would be challenging as there is limited adequate space in this area to install permanent structural elements and the necessary works would considerably impact operations as it would require significant outages on the "M" Ladder, and Tracks 1X, 3D, and 4D. In addition, the proposed track realignment would require that the columns be relocated to the south of the existing column locations, which would increase the framing span and increase the required depths of the structure members. Therefore Option 4, while slightly inferior to Option 3 from an operational point of view since Tracks 2, 3 and 4 feed through a single point, was determined to be the preferred option.

As the preferred option, the conceptual track design proposed in Option 4 was then further developed and significant revisions were made to properly incorporate additional architectural, structural, track, operational, and geotechnical considerations and to address preliminary comments received from NJ TRANSIT. A track alignment plan and schematic for the final conceptual version are included in Appendix A (Drawings TK-011, TK-012 and TK-013). For reference, the most significant improvements made included:

- The addition of a LH crossover between the "T" and "R" Ladders near Track 6D to mitigate the mentioned choke point on the "M" Ladder. Tracks 3D, 4D and 5D would be partially removed to support this modification since once HRT is completed they would no longer be needed for storage purposes.
- Revised connection to "E" Yard Tracks to allow future use of Tracks 2E, 4E and 5E with available lengths between 260 ft and 340 ft.
- Improved track layout to provide connectivity to Tracks 7E and 1D.
- Revised track horizontal curves within the platform areas to address egress concerns and minimize platform gaps and ensure it is within the maximum 13 inches gap allowed by NJ TRANSIT Guidelines and Standards Manual.
- Modified track alignment to increase track centerline to track centerline spacing to provide suitable areas for relocation of impacted columns.
- Revised track layout to reduce number of columns impacted.
- The location of proposed Platform A was shifted slightly to the west to improve passenger connectivity and minimize impact on the 7th Avenue Subway based on architectural considerations.

- A 150-foot long engine pocket on Track 5D was added to allow for storage of two (one dual mode, one electric) locomotives such that they could reach the NRT, the HRT and the Empire Line, albeit via double reverse moves.

Once the design of Option 4 was considered optimal, the two concepts (extending Platforms 1 and 2 to the west and building a new platform under 31st Street and Block 780) that had been combined into one optimized design in the revised Option 4 were separated back into two alternatives 12 and 14, now fully compatible. This separation allowed for an independent evaluation of the two original alternatives (Alt 12 and 14) and provides NJ TRANSIT with the information required to consider advancing either one of the alternatives independently, or both of them together or in phases. The respective conceptual design drawings for the two alternatives are included in Appendix A. From a track perspective, minor revisions were made on the separated designs to provide additional track connections (for example to "E" Yard) that became feasible when considering the alternatives individually. However, no changes were made to the alignment of the proposed ladders or platform tracks. The small modifications made are further explained and justified in each alternative specific report section.

As stated, the proposed track alignments support advancing both alternatives. The proposed design is not compatible with the track alignment currently proposed for the Amtrak Penn Station Expansion (PSE) concept, which would build three additional platforms south of the new platform proposed on Alt 12. The concept currently being considered by Amtrak locates the new platforms further to the East (between Blocks 780 and 806) and therefore both the platform tracks and the alignment of the new proposed ladders would not be compatible with Alts 12 or 14 proposed in this document. However, the PCIP work included development of a potential PSE conceptual track layout that would provide the same number of new platforms and that would be compatible with Alts 12 and 14. Appendix A includes, under "PSE Compatibility" in Supplementary Drawings, the track plan, track design, and track schematic drawings showing the combined track layout for the two alternatives and the revised PSE.

Finally, while the proposed design ensures that the alternatives are compatible and do not preclude a "PSE type" expansion to the south, track layouts could be optimized to support the advancement of only one of the two alternatives and to preclude the other alternative or the PSE concept (for example, if the PSE concept is not advanced). If an optimized design for advancing only one alternative was desired, development of that track layout would be completed as part of a separate study or as part of an expanded PCIP scope of work.

6.4 Alt 12: New Platform Under 31st Street and Block 780

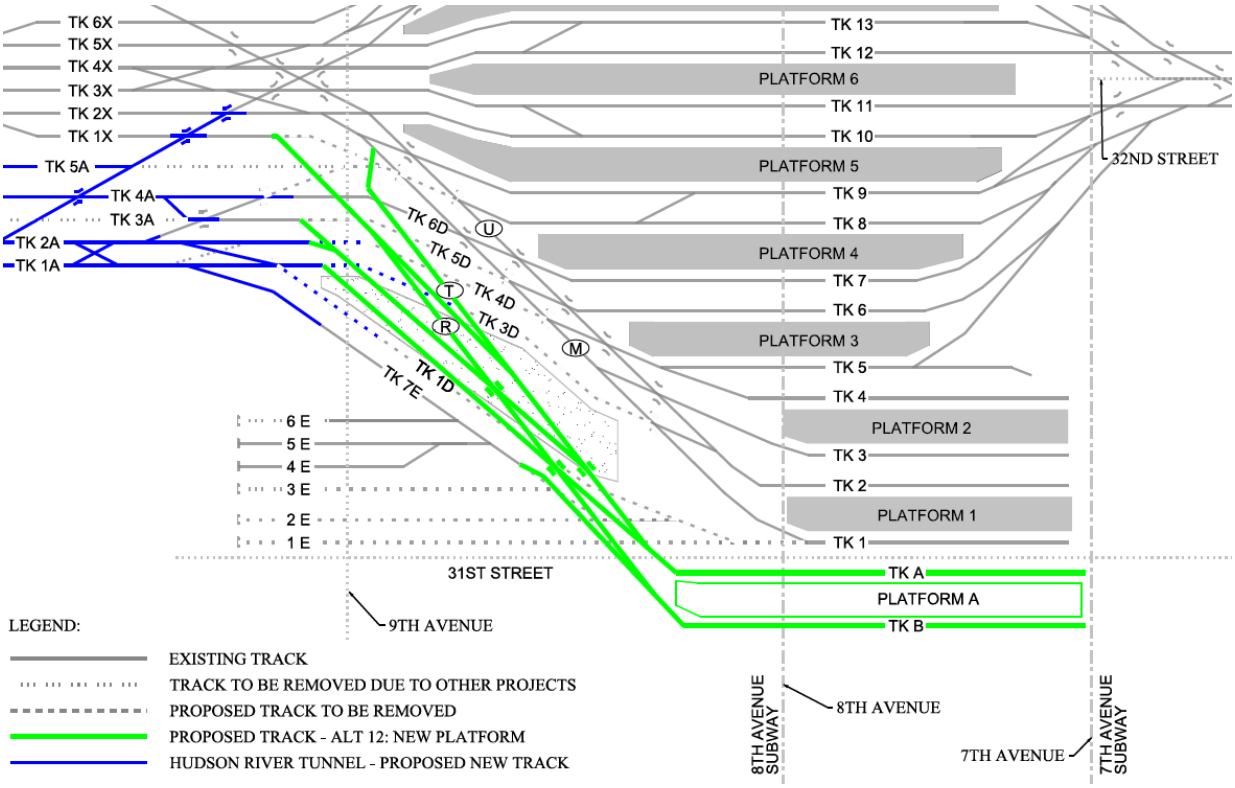
6.4.1 Alternative Description

The proposed Alt 12 would build a new platform (referred to as Platform A) and two new tracks south of existing Platform 1 to provide additional platform capacity at PSNY. Moreover, this alternative would provide additional connectivity between the new proposed platform and the West End Concourse, the Exit Concourse, the planned extension of the Central Concourse

and the NJ TRANSIT East End Concourse and would build a new concourse (referred to as Concourse A) above Platform A to improve east-west pedestrian circulation.

The proposed track schematic for Alt 12 is shown in Figure 14. The approximate locations of the streets and NYCT subway lines are also included for reference. Conceptual track design and alignment drawings as well as the conceptual architectural drawings for this alternative are included in Appendix A.

The proposed two new platform tracks would be connected to new "T" and "R" Ladders that would support parallel moves and provide connection to the existing NRT and the planned HRT. The proposed new Platform A would be 1020 feet-long to support 12-car train consists and would be located south of Track 1, below 31st Street and the northern portion of Block 780. The conceptual design location of the new platform minimizes potential impacts to the existing historic St. John the Baptist Church, as described in Section 5.5 of this report, and the 7th Avenue Subway, which is one of the key differences between this alternative and Amtrak's proposed design (Alt 13). While the location of the platform reduces the anticipated impacts on all the buildings on the north side of Block 780, it would require the complete removal of the PSNY south retaining wall, which would be a significant engineering challenge. Nevertheless, the preliminary conceptual review performed as part of this project has developed a conceptual feasible approach to removing the retaining wall.



Source: Developed for the PCIP Study.

Figure 14: Alt 12 Proposed Track Schematic.

While the basic concept for Alt 12 has not changed from the option that was proposed and described during the preliminary development and evaluation of alternatives, the design was further developed to incorporate architectural, structural, track, and geotechnical considerations and to address preliminary comments received from NJ TRANSIT and Amtrak.

6.4.2 Track Design

Alt 12 proposes a new island platform and two new tracks south of Platform 1. The new proposed Tracks A and B would run parallel to the existing east-west platform tracks and would be at a similar elevation; approximately 45 ft below the street level). On the west, Track A would be connected to the new "T" and "R" Ladders that, with a similar configuration to the existing "U" and "M" Ladders, would provide access to both the NRT and the HRT tunnels. Track B would also be connected to the "R" Ladder and Track 7E, which would provide access to a reconfigured "E" Yard. The two new ladders would be partially located on the footprint of the existing, unused Diagonal Platform. Removal of a portion of this platform and the relocation of a considerable number of columns would be required to allow for the installation of the new two ladders and associated track connections. On the east, the two tracks are shown to extend 20 feet beyond the end of the platform to provide an allowance for the installation of bumping posts while minimizing impacts to the 7th Avenue Subway. The bumping post configuration, design, and distance requirements would need to be studied further as part of a future study.

The new "T" Ladder would be connected to the "M" Ladder with a new No. 8 turnout located where Track 5A, which would be removed, currently crosses the "M" Ladder. Nevertheless, this new connection would not create a choke point in the "M" Ladder as several connections are provided between the "T" and the "R" ladders via double slip switches and turnouts that would provide operational flexibility and would not constrain the parallel moves capabilities of the existing track layout. The new "R" Ladder would be connected to the existing Track 1X.

Moreover, to allow for the installation of the two mentioned new ladders and associated track connections, Track 3D and the section of Tracks 4D and 5D that connect to Track 5 and Track 6 respectively would be removed. While these modifications would certainly impact "D" Yard, the design proposed would provide similar functionality. "D" Yard dates from the era when baggage and sleeper cars were routinely switched from one train to another which is no longer the case. These tracks are mainly used now to store locomotives such that they can reach the NRT and the Empire Connection (via double reverse moves). Both new platform tracks would have connections to Track 3D, 4D and 5D. The design developed provides approximately 150 ft between fouling points on Track 5D, which would allow to use this track for storing two locomotives (one dual mode, one electric) which would have access (via double reverse moves in some cases) to the NRT, the Empire Line, and the planned HRT. Track 6D, which would provide access to tracks south of Track 7 via the "T" and "M" Ladders, was been maintained and diamond crossings would be installed where it crosses the "T" and "R" Ladders.

Track B would also be connected to a reconfigured "E" Yard via Track 7E. Tracks 3E and 6E are currently proposed for partial removal due to modifications proposed as part of a different project. This alternative would completely remove Tracks 1E, 2E, 3E and 1D. This is not

considered to be a major flaw since "E" Yard has not been considered of critical importance as it is expected that it will no longer be used as mid-day storage for full train consists if Platforms 1 and 2 are extended. As a result, it is expected that "E" Yard will be utilized primarily to store maintenance of way equipment and therefore the removal of the yard trackage is not considered a significant issue. The design proposed has suggested feasible connections to "E" Yard tracks, while not precluding a potential Penn Station Expansion Project. However, connectivity to "E" Yard should be further studied in the next design phase.

Proposed Platform A was designed to be 25 feet wide by 1020 feet long. This platform length, which is the same as that proposed as part of the ARC project, is the minimum necessary to support a 12-car train consist. The proposed platform width, while slightly narrower than the NJ TRANSIT desired 26 feet, meets the applicable code requirements and provides adequate egress capacity and space for pedestrian circulation as discussed in the Architectural design section. Further study of the feasibility of increasing the platform width to the desired 26 feet would be recommended should the project advance. It is expected that more detailed study of existing conditions and refinement of structural requirements would reveal the additional space requirements could be met.

The conceptual design proposed minimized the degree of curvature used on Platform A while 1) providing connections to the existing NRT and proposed HRT that would support parallel moves, 2) minimizing impact on the 7th Avenue Subway and the historic buildings south of 31st Street, including the St. John the Baptist Church and the Affinia hotel, and 3) providing a new 1020 ft-long platform to be able to support 12-car train consists.

The proposed design includes a degree of curvature of 2°30', which would result in a maximum platform gap of slightly less than 12 inches, along the west end of the new Platform A. The length of these curved platform areas is less than 200 ft when measured from the west end of the platform. In many cases these platform areas would not be used, such as for shorter trains or when locomotives are on the west end of the train consists. While, NJ TRANSIT Station Design Guidelines indicates that the desired maximum platform curvature is 1° 40', the requirement is that the edge gap shall not exceed 13 inches and justification is required when platform curves exceed 1° 40' curvature. It is expected that the significant spatial constraints imposed by the existing conditions at this station would justify exceeding the desired maximum platform curvature requirement.

Alternatively, the Study Team reviewed the option of using more severe (but shorter) 12°30' curves to reduce the length curved platform and to limit the platform edge gap exceeding 13 inches to the westernmost car. In this way, the platform edge gap exceeding the standard would not be along a passenger car when trains are operated in push mode into the station; if trains were operated in pull mode into the station, it would require passengers in the last car to move to the next car before alighting. This approach was reviewed but is not recommended since it would require careful operations and would present safety risks should operational restrictions not be followed.

As described in Chapter 6 of this report, Alt 12 was developed in coordination with Alt 14 (westward extension of Platforms 1 and 2) to ensure that the alternatives are compatible and

that both could potentially be advanced. This development approach has provided a potential path to incremental investments that would allow NJ TRANSIT to realize capacity improvements at PSNY over time. While the proposed track alignments support advancing both alternatives, a more optimal track layout could be developed if only Alt 12 was advanced, and Alt 14 and the PSE expansion were precluded.

6.4.3 Architectural Design

Alt 12 proposes a new platform (Platform A) south of existing Platform 1. Platform A extends from the 7th Avenue Subway west under both the 8th Avenue Subway and the proposed extension of the West End Concourse to support a 12-car passenger consist. A new concourse is proposed above Platform A and below 31st Street with vertical circulation elements connecting Concourse A to both the platform and streetscape. Additionally, the West End Concourse would be extended south to provide egress capacity and improved passenger connectivity with vertical circulation elements to both the platform and streetscape. Alt 12 would provide increased platform capacity but would requires significant additions and modifications to existing infrastructure.

The architectural design of Alt 12 was developed to a level of detail sufficient to support the alternatives feasibility assessment and alternatives evaluation. The conceptual architectural drawings were developed to show the general arrangement only with no detailed floor plans or program requirements. The drawings illustrate the proposed station and platform access points and egress capacity requirements, concourse extensions, and connectivity with Penn Station, Moynihan Train Hall, and the streetscape. A preliminary egress analysis was performed based on the requirements of Amtrak, who is both the owner and the authority having jurisdiction (AHJ) of PSNY. This preliminary analysis included an NFPA 130 egress calculation for platform egress. Ridership analysis, which typically forms the basis for a typical NFPA 130 egress calculation, was not included as a part of this study.

Moving forward, an in-depth ridership analysis and survey of the existing conditions along with a programing study and inventory of the existing spaces within Penn Station impacted by this proposed alternative would be required to develop a preliminary engineering level of design.

6.4.3.1 Egress and Access Capacity Analysis Assumptions

To support the alternatives feasibility assessment and alternatives evaluation, this project assumed the following egress and access capacity criteria for Alt 12:

- Amtrak is both the owner and the authority having jurisdiction (AHJ) of PSNY.
- Based on the requirements of the AHJ, the following codes are considered:
  - NFPA 130 – Platforms
  - NYCBC 2014 – Concourse/all other areas
- A ridership analysis, which forms the basis for a typical NFPA 130 egress calculation, was not included as a part of this study.

- Instead, the preliminary egress analysis assumes a 12-car passenger consist with a train occupancy load of 130 passengers per car or approximately 1,600 passengers per train.
- Preliminary analysis assumes current arrival and departure queuing procedures will remain to offset overloading of platforms.
- Assumed platform load of two fully loaded trains: 3,200 passengers.

6.4.3.2 Connectivity to PSNY and Passenger Circulation

The additional new platform proposed in Alt 12 provides multiple opportunities to improve PSNY connectivity and passenger circulation. To provide egress capacity as well as improve passenger connectivity from Platform A, Alt 12 has proposed Concourse A, which was strategically located below 31st Street and perpendicular to the existing main concourses of PSNY. Concourse A offers passengers improved connectivity and greater flexibility when arriving and departing PSNY with connections to the Exit Concourse, the planned extension of the Central Concourse, and the NJ TRANSIT East End Concourse.

Alt 12 proposes vertical circulation elements, including egress stairs, escalators, and elevators from Platform A to Concourse A, as well as vertical circulation elements, including egress stairs and elevators from Concourse A to 31st Street. One of the vertical circulation cores, Stair AS-1, was prominently located at the northeast corner of 31st Street and 8th Avenue to serve as an additional main entrance to the station. This main entrance mirrors proposals from the Penn Station Visioning Study. The remaining three vertical circulation cores from Concourse A to 31st Street are evenly distributed along the south side of 31st Street. Stair AS-2 is located at the southeast corner of 31st Street and 8th Avenue and would require acquisition and demolition of an existing property, Jimmy's BBQ. Stair AS-3 is located midblock in the corner of a six-story parking garage adjacent to the Amtrak Service Building. This stair would require acquisition of a portion of that property and partial demolition and/or modifications to the existing parking garage. Stair AS-4 is also located midblock and would require acquisition and demolition of a portion of the building north of St. John the Baptist Church.

Alt 12 also proposes extending the West End Concourse south with vertical circulation elements, including egress stairs and an elevator from Platform A to the West End Concourse and egress stairs from the West End Concourse to Moynihan Train Hall and the streetscape. The egress stair from the West End Concourse to 31st Street is an egress-only emergency stair. The Study Team investigated a series of alternate egress-only stair location options from the West End Concourse to 31st Street. Those options are documented in the drawings included in Appendix A.

6.4.3.3 ADA Accessibility and Egress Compliance

ADA accessibility and egress compliance are provided by evenly distributed vertical circulation elements, including stairs, escalators, and elevators along Platform A to both Concourse A and the West End Concourse Extension. Stairs and escalators were configured in pairs providing access to Concourse A with elevators positioned between each pair of stairs and

escalators. Due to the curvature of the west end of Platform A, there is not enough width for both a stair and escalator; therefore, stairs and an elevator only were provided at this location.

The preliminary egress analysis assumes a 12-car passenger consist with a train occupancy load of 130 passengers per car and approximately 1,600 passengers per train. Two fully loaded trains totaling 3,200 passengers was used as the basis for the NFPA 130 platform analysis. Based on these metrics and the vertical circulation distribution described above, the preliminary NFPA 130 analysis found the platform evacuation time to be below four minutes and walking time to a point of safety to be below six minutes.

6.4.3.4 Synergies with Other Near and Long-Term Projects

A comprehensive review by the Study Team of all other near- and long-term projects associated with PSNY was performed under Task 1 of this study as previously described. Based on that review, relevant near- and long-term projects were identified for further evaluation to identify synergies between those projects and the alternatives developed for the PCIP. The projects with synergies with PCIP are listed below:

- **Penn Station Visioning –** The Penn Station Visioning Study proposes an open concourse with a grid layout that aligns with the existing main concourses. The Vision Study includes a large concourse to the south that covers Platforms 1 and 2 as well as provides access to those platforms. Similarly, Alt 12 proposes a concourse that connects the Exit Concourse, the planned extension of the Central Concourse, and the NJ TRANSIT East End Concourse to Platform A. This concourse will run immediately to the south of the concourse proposed in the Vision Study.
- **Moynihan Train Hall** – The West End Concourse of Moynihan Train Hall does not extend to Platform A. Alt 12 proposes extending the West End Concourse to provide direct access to the new platform, improving vertical circulation and pedestrian connectivity.
- **PSNY Central Concourse** – The PSNY Central Concourse is a near-term project that would extend the existing Central Concourse to the south of PSNY. This project has been assumed as part of the baseline of the PCIP Study. Platform A would connect to the south end of the planned extension of the Central Concourse, improving pedestrian connectivity.
- **Amtrak Penn Station Expansion Project –** The proposed Amtrak Penn Station (PSE) concept would provide four new platforms south of Platform 1, under 31st Street and Blocks 754, 780 and 806. Alt 12 proposes an alternative location and alignment of the first of the four new platforms proposed in the PSE concept. The platform and concourse expansions proposed in Alt 12 do not preclude expansions proposed in the PSE concept, however modifications would have to be made to the PSE design as proposed by Amtrak. Alt 12 could potentially serve as the first phase of a larger master plan and Concourse A proposed on Alt 12 could potentially provide connection to the platforms and concourse proposed as part of the PSE concept.
- **HSR** – As part of the Gateway Program, Amtrak develop a concept for a new High-Speed Rail Concourse that would connect Moynihan Station with a future new deep-level HSR

station under the four new platforms that would be developed as part of the PSE concept. The High-Speed Rail Concourse proposed is divided into the upper concourse above the commuter rail and the lower concourse levels below the commuter rail platform level. The upper HSR Concourse could potentially connect directly to the extension of the West End Concourse proposed by Alt 12. Alt 12 would not preclude the implementation of the HSR station project; however, some modifications to the HSR project and Alt 12 would be required in the future to ensure adequate connectivity is provided.

6.4.4 **Constructability Review**

6.4.4.1 Structural Considerations

The design of new Platform A and two new tracks under 31st Street requires several important structural design considerations: the removal of the retaining wall, underpinning existing subway overpasses, and underpinning impacted buildings along 31st Street. Conceptual level structural sequencing and implementation approaches were developed for these elements using the available information on the existing PSNY structure and limited information on the existing buildings and site conditions. It is expected that the conceptual sequences and schemes proposed as well as the assumptions considered would need to be verified during further studies and would be informed by more detailed collection and study of information on the existing structures and impacted buildings, and additional on-site structural and geotechnical investigations.

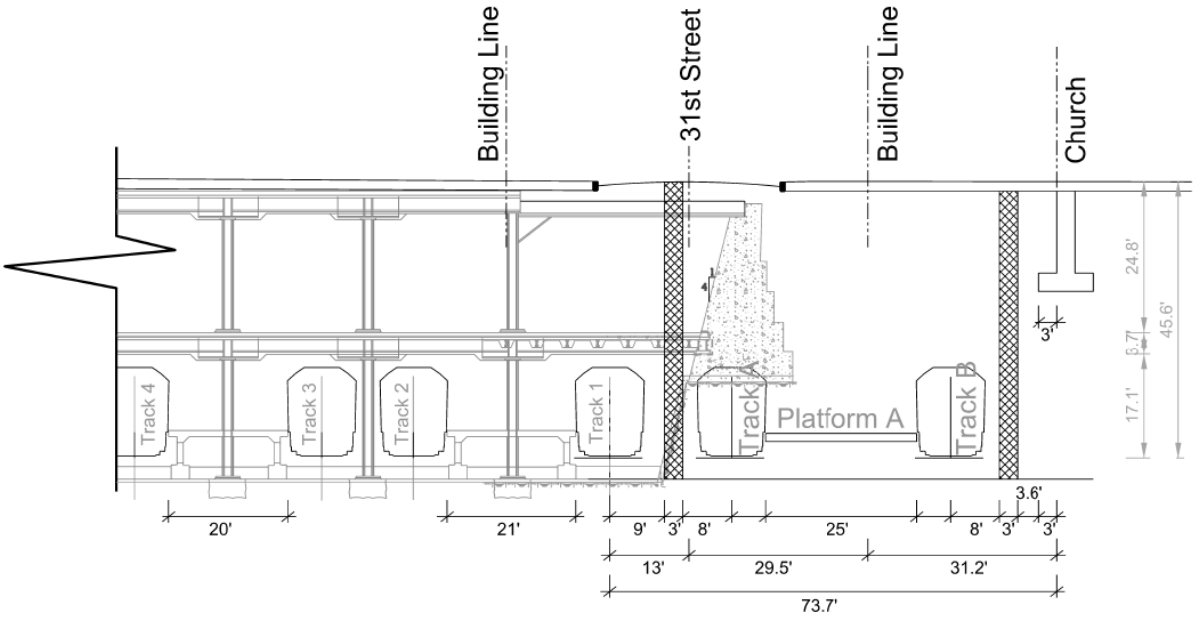
6.4.4.1.1 Removal of 31st Street Retaining Wall

The north side of Block 780 consists of five low-rise buildings, a 15-story and a 17-story office building. One of the low-rise buildings is the Amtrak Service Building (former Electric Generating Station) located in the middle of the block. The southeast side of Block 780 is the location of the St. John the Baptist Church, a historic masonry building. Since the church is a historic landmark, the location for the new platform and tracks were set to avoid underpinning the church to minimize impacts to this building. However, this locates Track A directly under the retaining wall, which requires completely removing the PSNY south retaining wall for the length of the new track, as shown in in Figure 15.

Based on historic geotechnical data, the rock stratum is assumed to be close to grade. A more in-depth geotechnical study would need to be conducted to determine the actual depth of rock. The buildings surrounding PSNY are assumed to be founded on rock. The geometry of the retaining wall, shown in Figure 16, was based on the information obtained from historic drawings and drawings developed under separate efforts. The accuracy of the dimensions in the drawing, and the actual condition and composition of the wall needs to be verified, so more investigative work will have to be done in future studies. The existing wall is unreinforced concrete founded on rock and is assumed to resist lateral earth and hydrostatic pressures as well as provide support for the existing PSNY south structural framing.

To remove the retaining wall, temporary columns and foundations would have to be installed adjacent to the wall on the existing Track 1 side. These columns would be the temporary

support for those components of the station while the wall would be removed. Once the wall is removed and new columns and foundations installed on the new platform, the roof and concourse girders could be cut back to column line and new girders installed to span between the columns adjacent to the existing track and the proposed track. Work associated with the reframing for the new platform and tracks is explained in more detail later in this report.



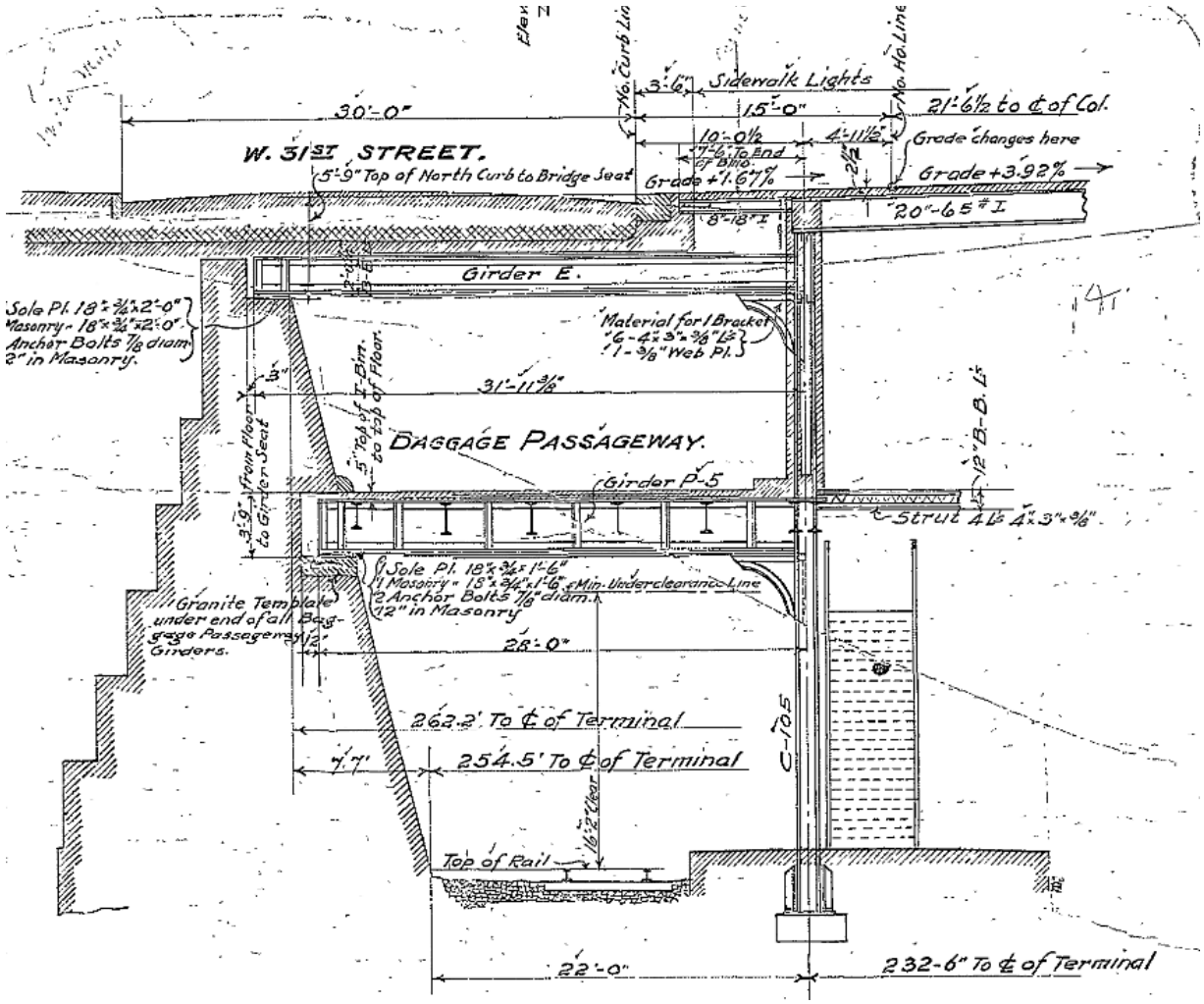
Source: Developed for the PCIP Study based on PSCE 30% Preliminary Engineering Design Drawings.

Figure 15: New Proposed Platform Location based on Clearances from Church Foundation.

6.4.4.1.2 Underpinning of the 7th and 8th Avenue Subways

The construction of proposed Platform A would extend below the 8th Avenue Subway line. While previous designs of this alternative required underpinning the 7th Avenue Subway line, revisions were made to relocate the proposed new Platform A to the west to minimize impacts to the 7th Avenue Subway. While the new platform footprint is outside the 7th Avenue Subway box, depending on the length of the bumpers and other necessary allowances, the two new platform tracks may require partially underpinning the 7th Avenue Subway line. Therefore, this section describes and considers the feasibility of underpinning both subway lines.

The two potentially-affected NYCT tunnel boxes are assumed to be on rock. The 7th Avenue Subway line was constructed in the late 1910s and the 8th Avenue Subway line was constructed approximately a decade later in the 1920s. The construction of the new platform and tracks below 7th and 8th Avenues would require excavation through rock and underpinning of the NYCT tunnel boxes. The underpinning and rock excavation would need to be carefully phased to avoid undermining the tunnel box. A detailed sequence for underpinning the NYCT subway for this alternative has not been conceptually developed during this preliminary assessment stage since the Amtrak Gateway project had already reviewed the constructability and developed schemes to underpin both subway lines. This indicates that the proposed platform location under the subway lines is conceptually feasible.



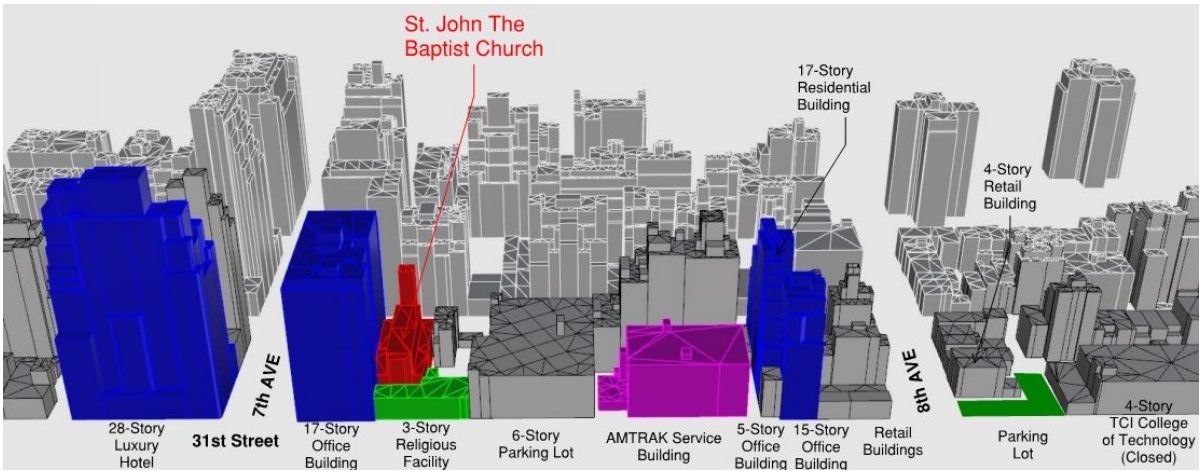
Source: PSNY Amtrak Historic – New York Terminal. Steel Viaduct Under 31st Street. DWG No. 11774. Aug. 25 1905.

Figure 16: Historic North-South Cross Section Showing the PSNY South Retaining Wall.

The underpinning work would require night outages and weekend General Orders for the impacted subway tracks, potentially taking one or two tracks out of service at a time. Close coordination with NYCT would be critical to minimize impacts to the subway service. Furthermore, the subway tunnels would have to be properly instrumented and monitored. Developing the construction sequence, the proposed structural framing configuration, and verifying engineering feasibility in detail would be required to advance the project including collection and review of additional existing conditions information and more detailed design.

6.4.4.1.3 Feasibility and Conceptual Approach to Building Underpinning

The proposed Platform A and two new tracks places part of the station expansion directly under the buildings along the north side of Block 780 and the northwest corner of Block 754. Figure 17 shows a 3D visualization of the main buildings of interested along the south side of 31st Street.



Source: 3D Model developed for the PCIP Study based on documentation and data compiled.

Figure 17: Buildings of Interest along the South Side of 31st Street.

Based on building size, use, and value, demolishing the low-rise buildings would likely be more cost-effective than underpinning them. The 28-story luxury hotel, the 17-story office building, the St. John the Baptist Church, the Amtrak Service Building, the 15-story office building, and the 17-story residential building have significant value and their size suggests that underpinning these buildings could be considered in lieu of demolition. However, underpinning these buildings would require loss of some of their basement area, which would be taken by the permanent subterranean construction. Temporary and permanent easements would be needed.

A general underpinning concept was developed to illustrate the feasibility of underpinning the buildings impacted by the expansion. The Structural Appendix includes the conceptual approach proposed to underpin the impacted buildings south of 31st Street. To further develop the underpinning for each of the specific buildings and verify its feasibility, extensive investigation and information gathering of the existing structures and site conditions would have to be performed, including additional structural analysis. The goal of the additional investigations and analysis would be to accurately determine the building loads, framing including any transfer structures, lateral system, foundation type, etc. It would also identify any areas that could potentially be problematic or have considerable risks. Table 6 shows a summary of the basic characteristics of the significant buildings of interests that could be impacted. Note that the design for the proposed new Platform A (Alt 12) would not impact the 28-story hotel (the Affinia hotel).

As previously mentioned, the rock elevation is expected to be relatively high in this area and therefore it is presumed that the existing buildings are founded directly on rock. From the available existing drawings and the information at the NYC Department of Buildings it can be concluded that some of the buildings have one or multilevel basements. Where the existing foundations are supported on rock, a micropile foundation method would be proposed to support the underpinning. This method is advantageous since the full structural capacity can be utilized in rock which makes it cost effective. The pile casings can be threaded to keep the segmented pile lengths short and allow a compact drill rig to be utilized in the low headroom

basements. The pile size and quantity would be dependent on the load being transferred and further analysis would be required as the design advances. However, for a rough estimate, based on a 10-inch diameter steel cased grouted pile with a 250 kip capacity, an interior column in the 17-story building would require approximately eight piles. The existing retaining wall that encloses the south side of PSNY below grade would need to be completely removed. The conceptual underpinning sequence, described in detail in the Structural Appendix, would begin with temporarily decommissioning Track 1 to allow installation of temporary columns, bracing, and foundations to support the existing concourse and roof framing. An excavation shaft along the sidewalk, north of the building line, would provide an access point to the building exterior and basement for the underpinning work. The excavation would only extend down to the existing foundation so as not to undermine it. With access to the perimeter of the foundation and rock surface, the micropiles could then be driven around the foundation and down past the proposed track slab elevation. A set of cap beams, columns, transfer beams, and jacks would then be installed to grab and lift the column. The column and existing foundation below the transfer could then be removed.

Building	Address	Construction type (assumed)	Year Built	Basement levels*
17-story office	370 7th Avenue.	Steel frame	1921	3 levels
Amtrak Service Building	232 W 31st St.	Steel frame	1900s	3 levels
15-story office	254 W 31st St.	Steel frame	1926	1 level
28-story hotel	371 7th Avenue.	Steel frame	1929	5 levels

Source: Basement levels shown are based on information obtained from the NYC Department of Buildings.

Table 6: Blocks 780 And 806 Buildings Considered for Possible Underpinning.

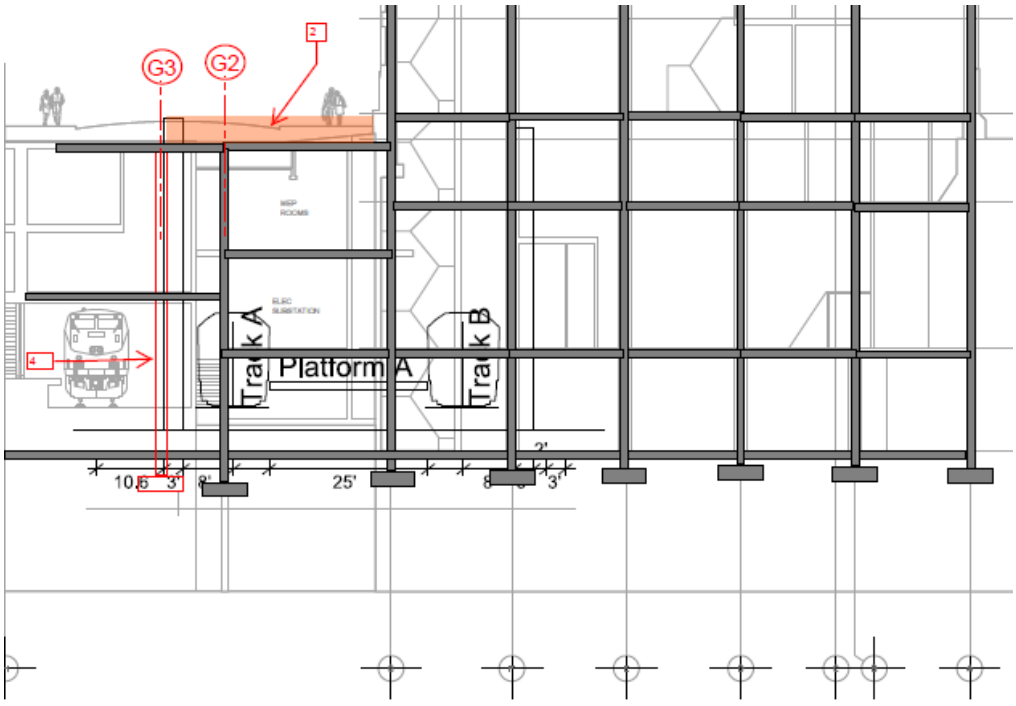
A staged excavation and removal of the retaining wall and rock would follow the removal of the existing foundation. The proposed excavation would be divided into several stages to allow installation of necessary bracing for the micropiles and rock anchors to stabilize the rock face. The micropiles would need to be braced laterally in short intervals to maintain the capacity and prevent any buckling of the structural members. Once excavation reached the approximate track level, new columns and foundations would be installed under the existing columns of the building. The new column line would fall within the width of Platform A. Building columns falling within the track clearance would be supported on transfer girders framing into the new column line and perimeter wall. Final building load transfer would be achieved by transferring the building loads from the temporary structure to the new columns and transfer girders. In addition, a new column and foundation line would be installed south of Track 1 to permanently support the existing PSNY framing. The temporary structure at Track 1 and under the building

would be removed and the remaining framing installed for the concourse, roof, platform and tracks.

The Amtrak Service Building is a 5-story steel building above grade with stone and brick facades. The building extends three stories below grade, which would require significant structural modifications to allow for the new proposed tracks and platform, see Figure 18. Since the foundation of the existing service building is at the same level as the PSNY foundation, the new track slab elevation falls within the building envelop and extensive rock excavation is not needed. Nevertheless, some localized excavation may be required to install new foundation onto rock.

The proposed expansion into the Amtrak Service Building footprint would require removal of existing Amtrak columns and framing at Grids F, and G from the 2nd basement level to the foundation and Grid G2. Currently these affected levels house various electrical, mechanical, and plumbing equipment servicing PSNY. A complete inventory of the existing utilities and equipment of the Amtrak Service Building was developed for the Amtrak PSE concept and is included in the project Phase 1 – Section 2A Pre-Final Report. Prior to commencing any underpinning work, these impacted services would have to be relocated to maintain station operations.

Further work would be required to analyze and understand which buildings would be sensible to underpin from a cost perspective. It is recommended that this decision be made based on a tradeoff analysis that adequately considers important factors such as building size, value and use, construction type, input from stakeholders and the potential underpinning cost.



Source: Developed for the PCIP Study.

Figure 18: North-South Cross Section of the Amtrak Service Building.

6.4.4.1.4 Relocation of Impacted Columns

In addition to the above-mentioned structural considerations, there are numerous PSNY columns that would require relocation. A plan and a list of the impacted columns is included in the Structural Appendix. Although the columns are spaced further apart, the construction would be like that of the 8th and 9th Avenue column relocation described in Section 6.6.4.1.1. Temporary supports and jacking would be required, and further investigation would be needed to develop the proposed reframing and pinpoint any trouble areas. Relative beam depths were inferred based on current column spacing (larger spans indicate deeper beams) but more information is needed on existing frame, columns, foundation, ground condition and clearances.

6.4.4.1.5 Other Considerations

Additional considerations include adjustments to NYCT subway track outage times, possibly having to conduct work in constrained spaces, and relocation of existing conduits, utilities and electrical, mechanical, fire safety and power equipment.

6.4.4.2 Potential Implications on Operations and Maintenance Cost

The modifications proposed by this alternative are expected to have a small increase on the current overall Operations and Maintenance (O&M) budget due to the construction of a new platform. The most significant implications on these costs are summarized below. However, comprehensive financial analysis by NJ TRANSIT would be required to develop a detailed O&M cost estimate as part of a future study. This is needed to properly assess and qualitatively estimate and evaluate these costs once preliminary engineering information is available. These include:

- Higher O&M costs related to security, cleaning, and passenger information system maintenance due to the proposed new platform, concourse and extension of existing concourses, and new stairs.
- Minor decrease in O&M costs associated with the removal of tracks at “E” and “D” Yards.
- Potential minor decrease on the O&M costs due to the removal of multiple double slip switches on the “U” and “M” Ladders. While this alternative proposes installing additional turnouts, the maintenance cost of these would be expected to be lower than the existing double slip switches. In total, this alternative would remove six existing turnouts and seven existing double slip switches while installing 13 new turnouts and two double slip switches.
- Slight increase in Rail Operations supervision and additional Maintenance of Equipment (Mechanical) support needs to properly support operations on the new platform.

6.4.4.3 Potential Implementation Phasing and Service Impacts

This alternative proposes substantial modifications to the existing PSNY track layout and it would require significant service outages from NJ TRANSIT, NYCT and Amtrak. While service outages on Track 1, "E" Yard and "D" Yard would be considerable and extensive, it is expected that the impact to the rest of the station and 8th Avenue Subway tracks could potentially be limited to weekend outages.

A suggested conceptual track staging plan is described below. However, comprehensive construction staging coordination with the Operations, Structural, Architectural, Track, Communications & Signals and Electric Traction/Catenary disciplines would be required to develop a detailed staging plan during preliminary engineering to minimize impacts to operations.

Stage 1 (weekdays): Relocation of impacted utilities and removal of 31st Street. Minimal impact to station operations anticipated.

Stage 2 (weekdays): Track 1 taken out of service. The south section of Platform 1 and some concourse level sections, including some back of house space, would be partially closed. Temporary bracing of south section of PSNY and relocation of impacted equipment. Building underpinning, including the Amtrak Service Building, and complete removal of the south retaining wall. See Appendix B for a suggested conceptual approach to underpinning of buildings.

Stage 3 (weekends outages): Underpinning of the 8th Avenue Subway. Weekend outages would be required on the 8th Avenue Subway Tracks, likely one or two tracks at a time.

Stage 4 (weekdays): Partial demolition of the Diagonal Platform, relocation of relevant impacted columns and removal of Tracks 1E, 2E and 3E and reconfiguration of "E" Yard. Impact to tracks would be limited to "E" Yard.

Stage 5 (weekdays): Installation of new PSNY south wall and foundations and removal of temporary bracing.

At the end of the construction of this stage, Track 1 would be back in service. To this point, only minor impact to other platforms tracks and the "U" and "M" Ladders.

Stage 6 (weekdays): Installation of slab, mezzanine and roof framing for new section of the station and new platform and Tracks A and B. Restoration of 31st Street.

Reduced impact to existing train operations at track level would be anticipated on this stage. Several concourse level sections, including some back of house spaces, would continue to be partially closed.

Stage 7 (weekdays): Partial installation of "R" and "T" Ladders including double slip switches, turnouts and connections to new Tracks A and B that would not impact existing operations and would not require outages on platform tracks. Minor impact to existing operations would be expected.

Stage 8 (weekdays): Removal of Tracks 3D and 4D and relocation of relevant impacted columns. The double slip switch connecting Track 4D to the "M" Ladder would be removed, and a new turnout would be installed during weekend outages. Tracks 3D and 4D are no longer in service.

Stage 9 (weekdays): Removal of Track 5D and installation of "R" Ladder and connections to Tracks 5D and 4D. Partial installation of "T" Ladder. The double slip switch connecting Track 5D to the "M" Ladder would be removed, and a new turnout would be installed during weekend outages. Track 5D would no longer be in service.

Stage 10 (weekend outages): Removal of Track 5A, connection of "R" Ladder to Track 1X and relocation of relevant impacted columns. The new turnout on the "M" Ladder providing connection to the "T" Ladder would also be installed. Weekend outages would be required for Tracks 5A, 6D, 1X and the "U" and "M" Ladders. Double slip switches connecting Track 5A to the "U" and "M" Ladders would be removed, and new turnouts would be installed during weekend outages. Track 5A no longer in service.

Stage 11 (weekend outages): Completion of "T" and "R" Ladders.

Stage 12 (weekend outages): Signal system cutover.

Stage 13 (weekend outages): Testing and commissioning.

6.4.4.4 Conceptual Cost, Schedule and Qualitative Risk Considerations

The order-of-magnitude cost estimate, includes $101.7 Million (unescalated) provision for soft costs and a 40% ($194.3 Million, unescalated) unallocated contingency. The total order-of magnitude cost estimate for Alt 12, including the projected escalation to midpoint of construction for this alternative, exclusive of costs associated with real estate acquisition, buildings demolition and underpinning, rolling stock costs and finance costs and including contingency, is $767.0 Million. This estimate, which was developed following the format required by FTA (SCC categories 10 thru 90), is consistent with AACE International (Association for the Advancement of Costs Engineering) best practices and is considered a Class 5 estimate.

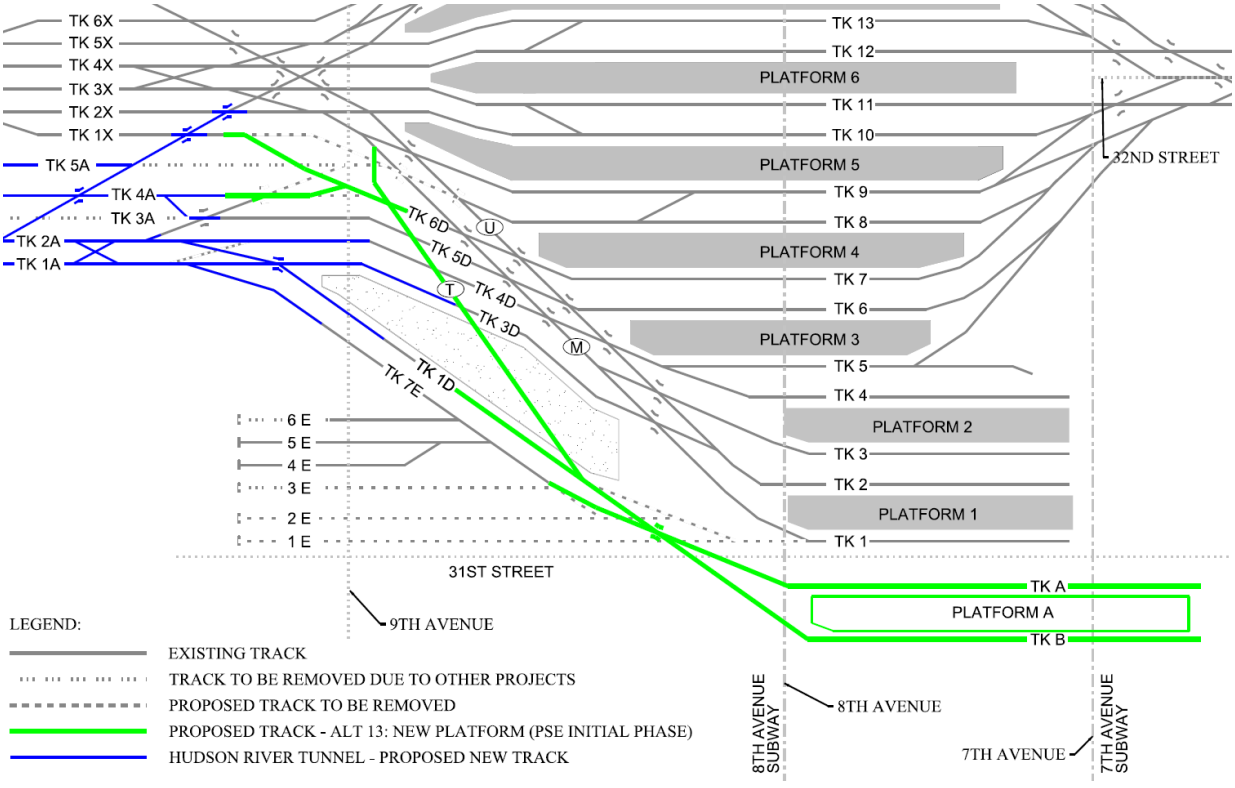
The conceptual schedule estimates that the total duration required to implement this alternative would be 1,820 days, or approximately seven years, including planning, design, and construction. The major risks for this alternative would be design challenges due to the existing spatial constraints, potential Force Account support concerns, underpinning of the 8th Avenue Subway and the buildings on the north side of Block 780, removal of the retaining wall, operational impacts during construction, and the usual design, construction, budget and schedule risks associated with a project at this location and of this scale. For additional details on the conceptual cost estimate, schedule and the qualitative overview of the main risk considerations, refer to Appendix C.

6.5 Alt 13: Initial Phase of Amtrak Penn Station Expansion Project – New Platform

6.5.1 Alternative Description

Proposed Alt 13 would build a new platform, designated Platform A, and two new tracks south of the existing Platform 1 to provide additional platform capacity at PSNY. Moreover, a new concourse level would be built above Platform A and would connect it to the existing Exit Concourse, the NJ TRANSIT East End Concourse as well as the proposed extension of the Central Concourse. The alternative's track layout was based on the Amtrak Penn Station Expansion (PSE) draft design and is included for comparison with Alt 12. Alt 13 proposes building just the first platform and associated track connections of the Amtrak PSE and it could potentially be the initial phase of this project if it were to be advanced.

The proposed track schematic for Alt 13 is shown in Figure 19 . The approximate locations of the streets and NYCT subway lines are also included for reference. Conceptual track design drawings are included in Appendix A.



Source: Developed for the PCIP Study.

Figure 19: Alt 13 Proposed Track Schematic.

The proposed two new platform tracks would be connected to a new "T" Ladder and to Track 1D and Track 7E, which would provide access to the three tracks maintained on "E" Yard (Tracks 4E, 5E and 6E). The "T" Ladder would be connected to the "M" Ladder where Track

5A, which would be removed, crosses the "M" Ladder. Therefore, both new platforms tracks would have access to the existing NRT and the planned HRT. The track layout considered in Alt 13 minimizes overall impact to PSNY as 1) it reduces the number of column relocations, 2) it minimizes the area of the diagonal platform impacted, 3) it only requires partial removal of the retaining wall, and 4) it minimizes the number of existing tracks to me removed. However, Alt 13 design would not support parallel moves to/from Platform A since it requires trains servicing both new platform tracks to feed through the same double slip switch.

The proposed new Platform A would be approximately 1090 feet long to support 12-car train consists and it will be located south of Track 1, in the north section of Block 780 and the west section of Block 806. Therefore, this alternative would require underpinning both the 8th Avenue Subway and the 7th Avenue Subway. The original plan developed as part of the Amtrak's PSE concept assumed that the impacted buildings south of 31st Street would be demolished; however, since this alternative would only build the first platform, it is assumed that not all impacted buildings would be demolished and that a tradeoff analysis would be performed to determine the feasibility of underpinning some of the key buildings to minimize the impact. It is assumed that two of the affected historic buildings, St. John the Baptist Church and the Affinia hotel, would be underpinned.

It is important to note that while conceptually Alt 13 has not changed from the option that was proposed and described during the preliminary development and evaluation of alternatives, Amtrak revised its design to include vertical curves before and after the special trackwork to locate the new station tracks at a deeper elevation. This would enable extending some of the proposed platform tracks below the 6th Avenue Subway to the east and would potentially allow further extension of these tracks to Queens to support run-through operations. The proposed design, however, requires the location of the special trackwork on a 1.5% grade, which is a concern. The relatively steep grade through the special trackwork does not comply with Amtrak standards and could present some significant maintenance concerns.

6.5.2 Additional Considerations

The design for Alt 13 was not developed as part of this project and it is shown for reference and comparison purposes only. The design files were obtained on December 2018 from NJ TRANSIT and Amtrak, as developed for the Amtrak Penn Station Expansion Project. The conceptual drawings showing this alternative are included in Appendix A. For additional information regarding this design, including structural, architectural or other considerations, refer to the Penn Station Expansion Project documentation. The only minor modification incorporated by the Study Team is the replacement of the No. 8 turnout with a No. 8 double slip switch to provide connection to Track 7E and "E" Yard.

It should be noted that the track design shown is just a portion of the Amtrak design for a new station with eight tracks and four platforms. Therefore, it is expected that if this conceptual alternative is advanced, the track alignment and associated track connections would be redesigned and optimized. For the full track layout of the Penn Station Expansion Project, refer to the relevant compatibility drawing in Appendix A.

6.5.2.1 Potential Implications on Operations and Maintenance Cost

The most significant implications on these costs are summarized below. However, comprehensive financial analysis by NJ TRANSIT would be required to develop a detailed O&M cost estimate as part of a future study. This is needed to properly assess and qualitatively estimate and evaluate these costs once preliminary engineering information is available. These include:

- Higher O&M costs related to security, cleaning and passenger information system maintenance due to the proposed new platform and concourse and the extension of existing concourses, and new stairs.
- Minor decrease in O&M costs associated with the removal of tracks at "E" Yard.
- Slight increase in Rail Operations supervision and additional Maintenance of Equipment (Mechanical) support needs are likely to properly support operations on the new platform.

6.5.2.2 Conceptual Cost, Schedule and Qualitative Risk Considerations

The order-of-magnitude cost estimate, includes $103.5 Million (unescalated) provision for soft costs and a 40% ($197.7Million, unescalated) unallocated contingency. The total order-of magnitude cost estimate for Alt 13, including the projected escalation to midpoint of construction for this alternative, exclusive of costs associated with real estate acquisition, buildings demolition and underpinning, rolling stock costs and finance costs and including contingency, is $793.6 Million. This estimate, which was developed following the format required by FTA (SCC categories 10 thru 90), is consistent with AACE International (Association for the Advancement of Costs Engineering) best practices and is considered a Class 5 estimate. It is important to note that this estimate is based on the conceptual cost estimate developed for the Amtrak Penn Station Expansion (PSE) concept. The PCIP Study Team updated the PSE cost estimate to 2019 dollars and revised it to include only the first platform and the associated track connections as proposed by Alt 13.

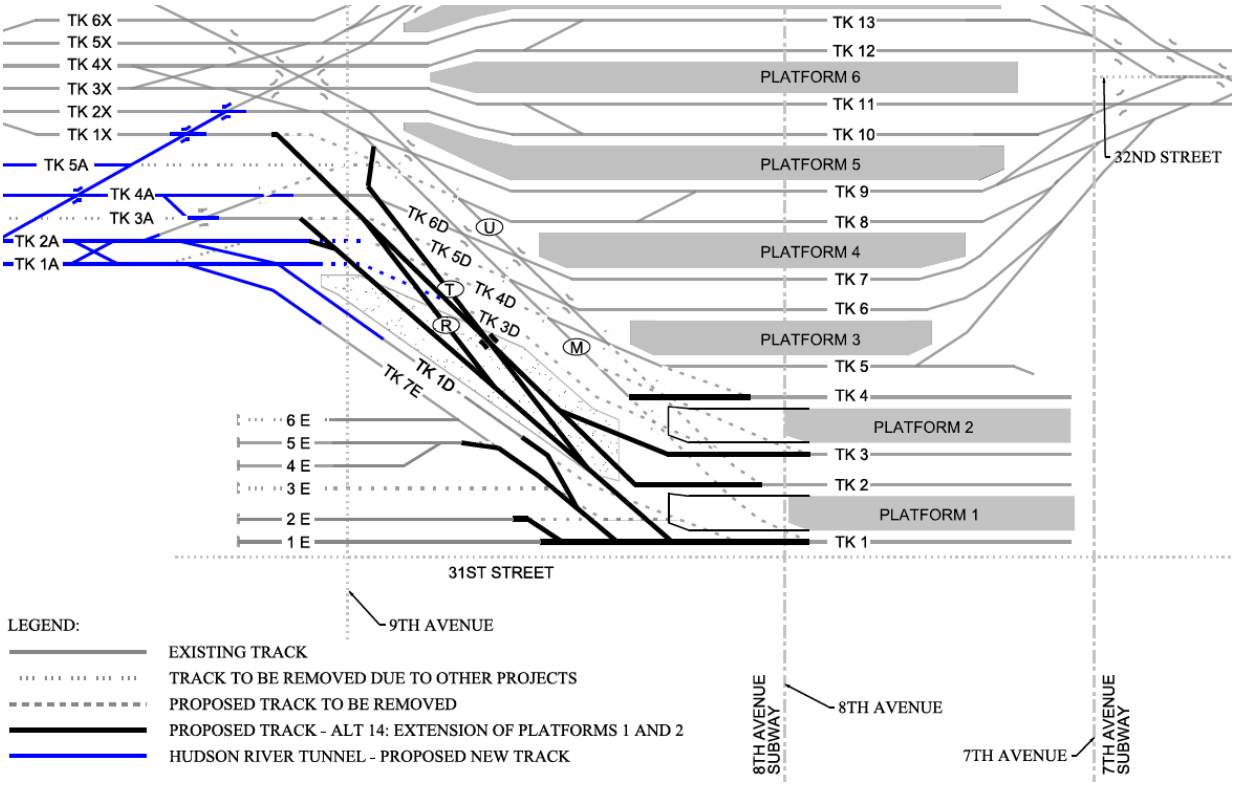
The conceptual schedule estimates that the total duration required to implement this alternative would be 2,072 days, or approximately eight years, including planning, design, and construction. The major risks for this alternative are the design challenges due to the existing spatial constraints; potential Force Account support concerns; underpinning of the 8th Avenue Subway and the 7th Avenue Subway; underpinning of the buildings on the north side of Blocks 780 and 806 including the historic St. John the Baptist Church and the Affinia Hotel; the partial removal of the retaining wall; the operational impacts during construction; and the usual design, construction, budget and schedule risks associated with a project at this location and of this scale. For additional details on the conceptual cost estimate, schedule and the qualitative overview of the main risk considerations, refer to Appendix C.

6.6 Alt 14: Westward Extension of Platforms 1 and 2

6.6.1 Alternative Description

Proposed Alt 14 would extend Platforms 1 and 2 west under the 8th Avenue Subway and West End Concourse to support full platform access for 12-car train consists. Alt 14 would provide additional vertical circulation connections between these two platforms and the West End Concourse and the Exit Concourse.

The proposed track schematic for Alt 14 is shown in Figure 20. The approximate locations of the streets and NYCT subway lines are also included for reference. Conceptual track design and alignment drawings as well as the conceptual architectural drawings for this alternative are included in Appendix A.



Source: Developed for the PCIP Study.

Figure 20: Alt 14 Proposed Track Schematic.

The conceptual track layout proposed would allow extension of Platforms 1 and 2 westward by approximately 250 ft and increase the overall length of these platforms to 1020 ft. This would increase train-seat capacity by enabling larger train consists to use these platforms, provide greater flexibility for platform assignments, and reduce train boarding and platform clearing times. The extension proposed is limited to the west side of the platforms and would have the same width as the existing platforms which are approximately 20 ft wide. Furthermore, this alternative would extend the West End Concourse south and provide new vertical circulation

elements including egress stairs and elevators from both platforms. Additionally, a new set of egress stairs would be provided from Platforms 1 and 2 to the Exit Concourse. These additional pedestrian connections would significantly improve the existing passenger circulation, especially on the south section of PSNY and would provide considerably greater flexibility to customers arriving or departing from any of these two platforms.

While Alt 14 has not changed from the concept that was proposed and described during the preliminary development and evaluation of alternatives, the design was further developed and significant revisions were made to properly incorporate additional architectural, structural, track and geotechnical considerations and to address preliminary comments received from NJ TRANSIT and Amtrak.

6.6.2 Track Design

This alternative proposes to disconnect Tracks 1, 2 and 3 from the existing "U" and "M" Ladders to allow for the westward extension of Platforms 1 and 2 and connects them to new "T" and "R" Ladders located on the east section of the Diagonal Platform. The two proposed Ladders would have a similar configuration to the existing "U" and "M" Ladders to support parallel moves.

The new "T" Ladder would be connected to the "M" Ladder with a new No. 8 turnout located where Track 5A, which would be removed, currently crosses the "M" Ladder. Tracks 1, 2 and 3 would also be connected to the new "R" Ladder, parallel to the "T" Ladder, that would provide access to the NRT via the existing Track 1X.

The existing turnout that connects Track 4 to Track 5 would be removed and Track 4 would be extended and connected directly to the "M" Ladder, removing the existing pinch point and supporting parallel moves of trains accessing these two tracks. Moreover, to allow for the installation of the two mentioned new ladders and associated track connections, Track 3D and the section of Tracks 4D and 5D that connect to Track 5 and Track 6 respectively would be removed. While these modifications would certainly impact "D" Yard, the design proposed would provide similar functionality. "D" Yard dates from the era when baggage and sleeper cars were routinely shuffled from one train to another which is no longer the case and nowadays, these tracks are mainly used to store locomotives such that they can reach the NRT and the Empire Connection (via double reverse moves). Track 1 would have connections to Track 4D, 5D. The design developed provides approximately 150 ft between fouling points on Track 5D to allow to use this track to place two locomotives (one dual mode, one electric) which would have access (via double reverse moves in some cases) to the NRT, the Empire Line and the planned HRT. Track 6D, which would provide access to tracks south of Track 7 via the "T" and "M" Ladders, has been maintained and diamond crossings would be installed where it crosses the "T" and "R" Ladders.

Track 1 would also be connected to "E" Yard and Tracks 1D and 7E. The available storage length on Tracks 1E and 2E would be reduced to approximately 600 ft. Track 3E, which is being partially removed due to modifications proposed as part of a different project, would be completely removed. Since Platforms 1 and 2 would be extended to support 1020-foot trains, it

is expected that the importance of "E" Yard would be significantly reduced as it will no longer be used as mid-day storage for full train consists. As a result, it is expected that, after the development of this alternative, "E" Yard will be mostly utilized to store MOW equipment and therefore the reduction of the available length for storage of Tracks 1E and 2E is not considered a significant issue.

Like the existing condition, the proposed design includes the installation of a new No. 8 turnout at the new extended end of Platform 1 to provide the connection to "E" Yard described above. Furthermore, the design aimed to minimize the degree of curvature used on the platforms while 1) providing connections to the existing NRT and proposed HRT that would support parallel moves, 2) minimizing impact on the 7th Avenue Subway, 3) providing a desirable connection to the West End Concourse, and 4) extending the platforms to 1020 ft to be able to support 12-car train consists.

The proposed design includes a 3° curve, which would result in a maximum platform gap of slightly less than 13 inches, along the extensions of Platforms 1 and 2. The length of these curved platform areas is less than 200 ft when measured from the west end of the platform. In many cases these platform areas would not be used, such as for shorter trains or when locomotives are on the west end of the train consists. While, NJ TRANSIT Station Design Guidelines indicates that the desired maximum platform curvature is 1° 40', the requirement is that the edge gap shall not exceed 13 inches and justification is required when platform curves exceed 1° 40' curvature. It is expected that the significant spatial constraints imposed by the existing conditions at this station would justify exceeding the desired maximum platform curvature requirement.

Alternatively, the Study Team reviewed the option of using more severe (but shorter) 12°30' curves to reduce the length curved platform and to limit the platform edge gap exceeding 13 inches to the westernmost car. In this way, the platform edge gap exceeding the standard would not be along a passenger car when trains are operated in push mode into the station; if trains were operated in pull mode into the station, it would require passengers in the last car to move to the next car before alighting. This approach was reviewed but is not recommended since it would require careful operations and would present safety risks should operational restrictions not be followed.

It is also important to note that, as described in Chapter 6 of this report, Alt 14 was developed in coordination with Alt 12 (build a new platform) to ensure that the alternatives are compatible and that both could potentially be advanced. This development approach has provided a potential path to incremental investments that would allow NJ TRANSIT to realize capacity improvements at PSNY over time. While the proposed track alignments support advancing both alternatives, a more optimal track layout could be developed if only Alt 14 was chosen to be advanced and precluding the other alternatives was acceptable. If this was the case, it is anticipated that the proposed track layout would be further studied and revised as part of the next phase of this Project or under a separate future study.

6.6.3 Architectural Design

As previously described, Alt 14 proposes extending Platforms 1 and 2 to the west under the 8th Avenue Subway and the proposed extension of the West End Concourse to support a 12-car passenger consist with additional vertical circulation connections to the extended West End Concourse and the existing Exit Concourse. These proposed connections would provide egress capacity and improve passenger connectivity. Alt 14 was developed to provide increased train seat capacity with limited impacts to PSNY infrastructure.

The architectural design of Alt 14 was developed to a level of detail sufficient to support the alternatives' feasibility assessment and evaluation. The conceptual architectural drawings have been developed to show the general arrangement only with no detailed floor plans or program requirements. The drawings illustrate the proposed station and platform access points and egress capacity requirements, concourse extensions, and connectivity with PSNY, Moynihan Train Hall, and the streetscape. A preliminary egress analysis was preformed based on the requirements of Amtrak, who is both the owner and authority having jurisdiction (AHJ) of PSNY.

Moving forward, an in-depth ridership analysis and survey of the existing conditions along with a programing study and inventory of the existing spaces within Penn Station impacted by this proposed Alternative would be required to develop a more detailed conceptual design.

6.6.3.1 Egress and Access Capacity Analysis Assumptions

To support the alternatives feasibility assessment and alternatives evaluation, this study assumes the following egress and access capacity criteria for Alt 14:

- Amtrak is both the owner and AHJ of PSNY.
- Based on the requirements of the AHJ, the following codes are assumed:
    - NFPA 130 – Platforms
    - NYCBC 2014 – Concourse / all other areas
- A ridership analysis, which forms the basis for a typical NFPA 130 egress calculation, was not included as a part of this study.
- The preliminary egress analysis of Alt 14 assumes an additional egress capacity of a three-car passenger consist with a train occupancy load of 130 passengers per car: approximately 390 passengers per train. The Study Team also investigated an option that would provide the necessary egress capacity to bring Platforms 1 and 2 to full compliance based on a 12-car consists.
- Preliminary analysis assumes current arrival and departure queuing procedures will remain to offset overloading of platforms.

- Alt 14 assumes an additional egress capacity load to each platform extension of two fully loaded three-car passenger consist trains: 780 passengers.

6.6.3.2 Connectivity to PSNY and Passenger Circulation

The proposed extensions of Platforms 1 and 2 in Alt 14 provide opportunities to improve PSNY connectivity and passenger circulation. To provide egress capacity as well as improve passenger connectivity, Alt 14 proposes extending the West End Concourse South with vertical circulation elements, including egress stairs and elevators from both platforms to the West End Concourse and egress stairs from the West End Concourse to Moynihan Train Hall. Additionally, a set of egress stairs was provided from both platforms to the Exit Concourse within the existing Penn Station. This approach provides passengers greater flexibility arriving and departing PSNY with direct access to the West End Concourse and existing Penn Station from Platforms 1 and 2.

6.6.3.3 ADA Accessibility and Egress Compliance

The existing vertical circulation elements of Platforms 1 and 2 do not provide the required egress capacity to support the current egress capacity loads. The planned PSNY Central Concourse Project which has been assumed as part of the baseline of this project improves those capacity issues but does not provide sufficient capacity to bring the referenced platforms into full compliance. The platform extensions proposed in Alt 14 would exasperate the capacity condition and require additional egress capacity be provided. To bring the platforms to full compliance based on the assumed egress capacity of two fully loaded 12-car passenger consists per platform, a minimum of four additional 5’-0” egress stairs would be required per platform. The intervention that would be required to provide all these vertical circulation elements exceeds the intent of this alternative due to the existing constraints of PSNY and the proposed level of intervention for Alt 14.

As such, Alt 14 provides sufficient egress capacity to support the extensions proposed by the alternative. Alt 14 provides ADA accessible elevators from Platforms 1 and 2 to the West End Concourse extension as well as additional egress capacity to support the load imposed by the platform extensions. The length of the platform extensions provides an additional three-cars to each consist with a total egress capacity of 390 passengers. This results in an added capacity of 780 passengers per platform. Based on a preliminary NFPA 130 egress calculation of this additional capacity three additional 5’-0” stairs are required from the platform to the concourses. Based on these metrics, a preliminary NFPA 130 egress analysis has found the platform evacuation time of the extensions to be below 4 minutes and walking time to a point of safety to be below 6 minutes.

The Study Team also investigated an option for Alt 14 that would provide the necessary egress capacity to bring the platforms to full compliance. This option would require a concourse extension west off the existing Exit Concourse to accommodate the egress capacity demands. This option has been documented in the appendix of this report.

6.6.3.4 Synergies with Other Near and Long-Term Projects

A comprehensive review by the Study Team of all other near- and long-term projects associated with PSNY was performed under Task 1 of this study. Based on that review, relevant near- and long-term projects were identified for further evaluation to identify synergies between those projects and the alternatives developed for the PCIP. The projects with PCIP synergies are listed below:

- **Penn Station Visioning –** No direct overlap with Alt 14. Alt 14 does not preclude the Penn Station Visioning Study proposed implementation.
- **Moynihan Train Hall** – The West End Concourse of Moynihan Train Hall does not extend to Platforms 1 and 2. Alt 14 proposes extending the West End Concourse to provide direct access to the platform extensions, improving vertical circulation to those platforms in particular, and the pedestrian connectivity throughout the extension in general.
- **PSNY Central Concourse** – The planned extension of the Central Concourse under the PSNY Central Concourse Project does not overlap with the extensions of Platforms 1 and 2 but does improve the egress capacity of the existing platforms and was assumed as a part of the baseline of this project.
- **Amtrak Penn Station Expansion Project –** The commuter rail aspect of the Amtrak Penn Station Expansion (PSE) concept will provide four new platforms south of the existing Platform 1, under 31st Street and Blocks 754, 780 and 806. The expansion of the West End Concourse proposed on Alt 14 could serve as a future connection to the platforms and concourse proposed as part of the PSE concept and would not preclude its implementation.
- **HSR** – As part of the Gateway Program, Amtrak develop a concept for a new High-Speed Rail Concourse that would connect Moynihan Station with a future new deep-level HSR station under the four new platforms that would be developed as part of the PSE concept. The High-Speed Rail Concourse proposed is divided into the upper concourse above the commuter rail and the lower concourse levels below the commuter rail platform level. The expansion of the West End Concourse proposed in Alt 14 would provide opportunities to connect with the potential HSR Concourse and would not preclude its implementation.

6.6.4 **Constructability Review**

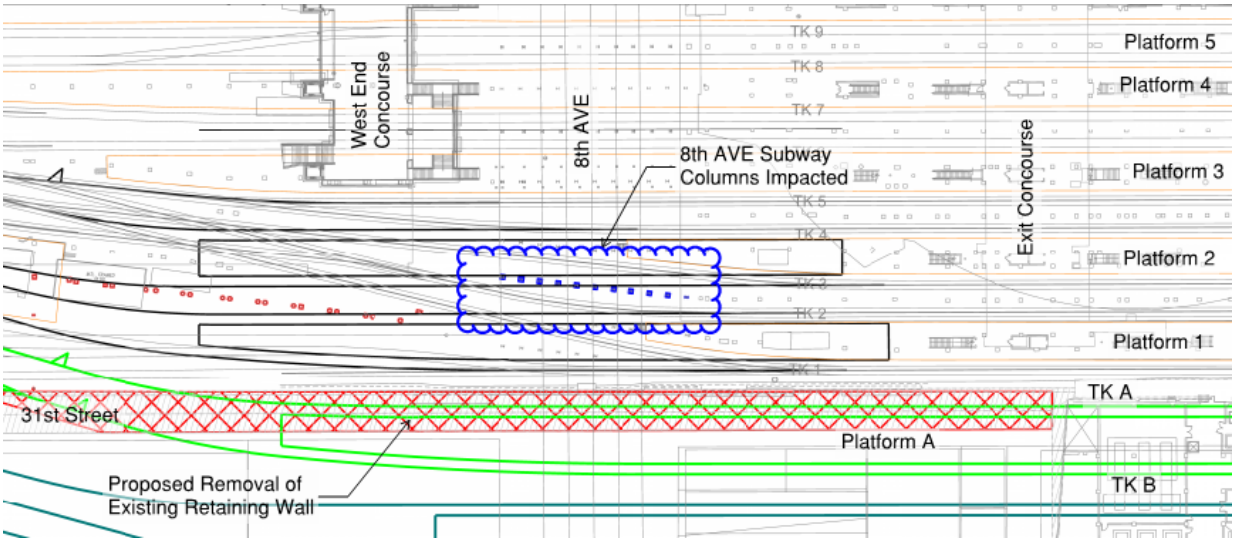
6.6.4.1 Structural Considerations

The proposal to extend Platforms 1 and 2 west to total 1020 ft and re-align associated tracks would require the removal of approximately 58 columns that support the mezzanine levels of PSNY and the Farley building and 13 columns supporting both 8th Avenue and the 8th Avenue Subway. The general feasibility of removing columns and subsequent re-framing of the

affected areas was evaluated on a preliminary basis. The feasibility of all sequences and schemes would need to be verified in future studies based on more detailed information and further analysis. In addition to the impacted columns under 8th Avenue, there are numerous other PSNY columns that would require relocation. For a complete list of these columns, refer to the Structural Appendix. Although the columns supporting the mezzanine levels are spaced further apart, the construction approach to column relocation would be like that described for the 8th Avenue Subway columns. While a conceptual review found that the relocation of impacted columns is feasible based on the preliminary review, temporary shoring, supports and jacking and weekend service outages would be required. Further investigation would be required to develop the proposed reframing and pinpoint any potential issues or areas of concern. Relative beam depths were inferred based on current column spacing (larger spans indicate deeper beams) but more information is needed on existing frame, columns, foundation, ground condition, and clearances.

6.6.4.1.1 Impact to 8th Avenue Subway

The proposed extension of Platforms 1 and 2 matches the existing platform width of approximately 20 ft and it would extend both platforms under the 8th Avenue Subway box, which currently has substandard overhead clearance, and beyond the West End Concourse. Tracks 1-4 would be realigned and would run parallel to the new platform extensions. Figure 21 illustrates the proposed platform extensions and highlights the impacted 8th Avenue Subway columns; refer to the Structural Appendix for larger scale images.



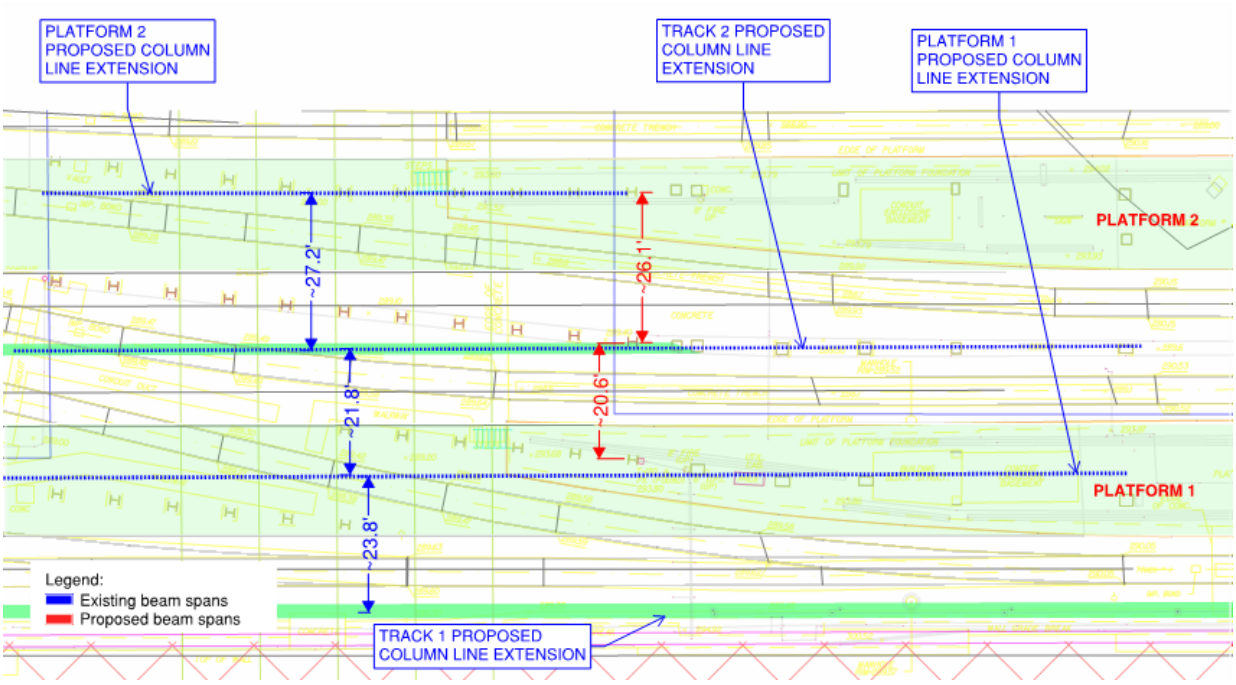
Source: Developed for the PCIP Study.

Figure 21: 8th Avenue Subway Columns Impacted by Alt 14.

Existing structural framing that supports the 8th Avenue Subway consists of closely-spaced built-up beams spanning to Penn Station girders and columns. The close beam spacing allowed for shallower structural depth members within the low clearance below 8th Avenue. Hence, the proposed layout was initially assessed to determine if the modified beam span lengths over the tracks would be within practical spans. Like the east end of the existing platforms, space for

column relocations is considered available within the 20-foot-wide platform extensions and in between the tracks. The results of this initial assessment are shown in Figure 22, where green areas indicate acceptable column relocation and existing columns to be relocated are highlighted in red. The current maximum column-to-column span is approximately 26 ft between columns on Platform 2 to the columns between Tracks 2 and 3. Likewise, spans between the track columns and columns on Platform 1 is approximately 20.6 ft with the proposed span increasing to 21.8 ft. The distance from columns on Platform 1 and the new line of columns adjacent to the retaining wall would be around 23.8 ft. Since the proposed column relocation increases the spans by a small margin, it was deemed reasonable to reframe the structure within the same structural depth and similar spacing.

As mentioned previously, extended Platforms 1 and 2 would run under the 8th Avenue Subway box. This is significant because of the reduced headroom and the desire to keep disruptions to the subway to a minimum. The low headroom requires special structural considerations since extra depth to beams cannot be added.



Source: Developed for the PCIP Study.

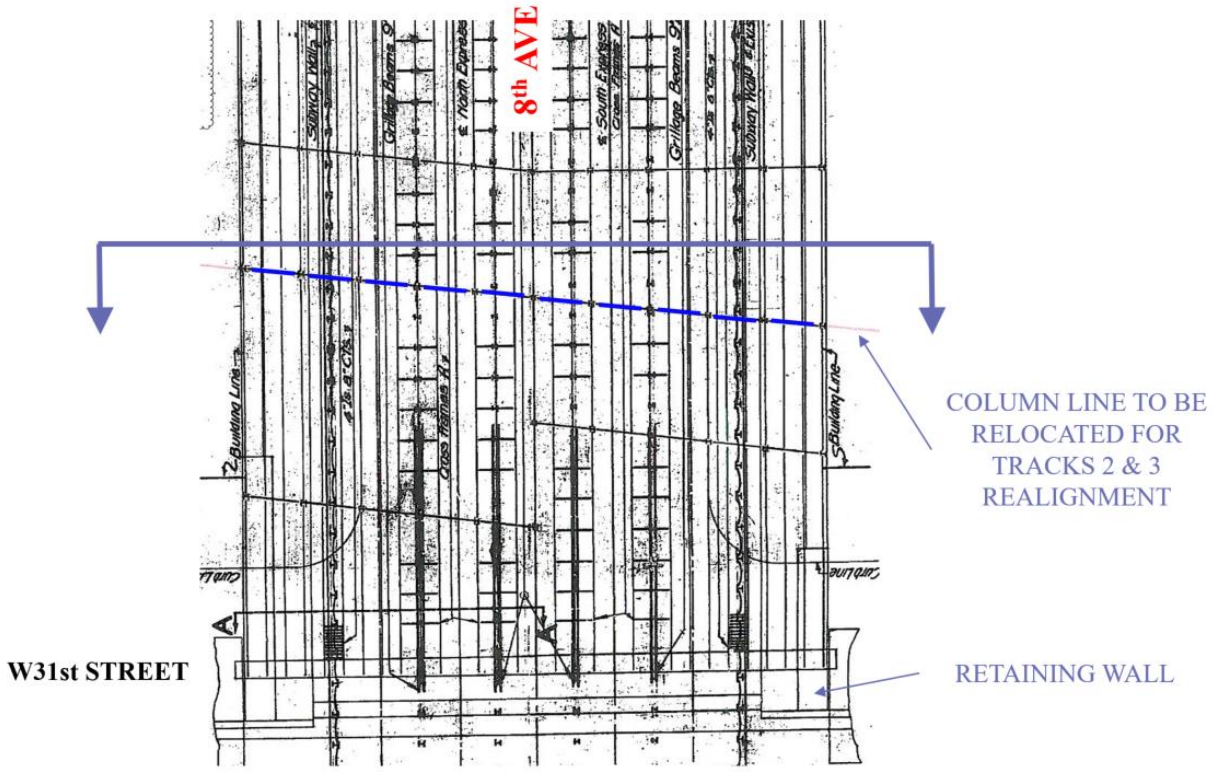
Figure 22: Existing and Proposed Beam Spans - 8th Avenue Subway Impacted Columns.

The available historic drawings of the 8th Avenue Subway and current Penn Station drawings were used to understand the framing configuration between these two structures. Figure 23 and Figure 24, which are based on the historic drawings of the 8th Avenue Subway, show the relevant framing plan and section of the NYCT structure. There are five tracks (two southbound, two northbound, and a storage track) in this section of the 8th Avenue Subway line. The existing NYCT structure consists of built-up steel columns and beams at approximately 5 ft centers with arched roof slab and arched walls spanning between the steel. The bench wall along the east and west sides contains duct banks and runs the length of the subway. Other

utilities noted are large sewer lines just outside of the subway walls and are assumed to be supported on the PSNY structure.

The 8th Avenue Subway above PSNY is a heavily utilized transit line serving the west side of Manhattan extending into Queens and Harlem. Load transfer of the 8th Avenue structure would undoubtedly impact the service. However, the preliminary structural review performed indicated that the service interruptions could potentially be limited to one or two tracks at a time by carefully sequencing the work. These service disruptions, which would need to be closely planned and coordinated with NYCT, could be scheduled on weeknights and weekends to minimize impact on subway operations, which would extend construction duration.

The proposed column relocations below the 8th Avenue Subway structure would have several associated significant challenges. These include limited structural depth due to already limited clearances, working below existing and active tracks, significant constraints and small tolerances due to closely spaced structures, and construction work limited to NYCT track outages on nights and weekends. Three conceptual alternatives were developed to illustrate the reframing and general construction sequence of the column relocations. For additional details, including sequence diagrams of the approaches proposed, refer to the Structural Appendix. Each alternative has its advantages and disadvantages and in all cases subway track outages would be required.



Source: Developed for the PCIP Study based on drawings obtained from NYCT Archives.

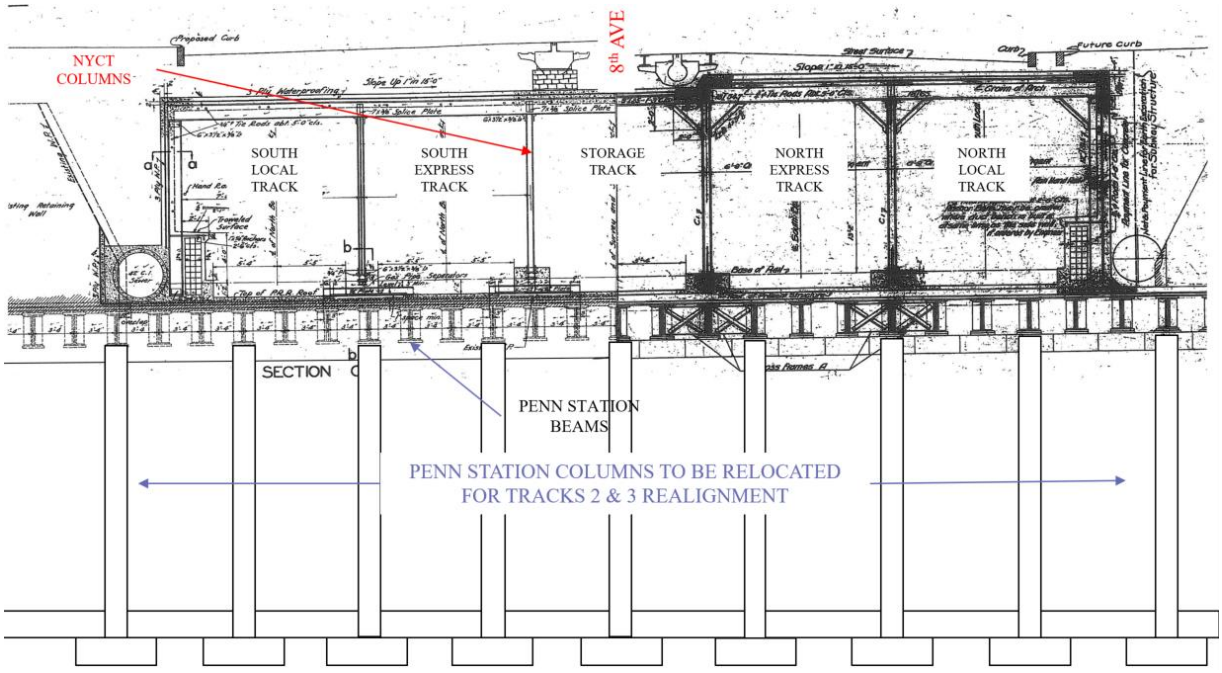
Figure 23: Plan View of the Existing 8th Avenue Subway Framing.

The three conceptual column relocation approaches proposed have some similarities which include installing netting or shielding above the subway tracks. The arched roof slab and walls under load are restrained by the steel beam and columns. Therefore, slight movement of the steel members could potentially weaken the arch effect and result in some spalling. Load transfer of structures requires carefully sequenced jacking operations, instrumentation, and monitoring to allow for a safe and controlled load transfer to occur.

Option A: Load transfer within NYCT tunnel

This option considers transferring the subway column loads by installing temporary transfer posts and foundations on rock to support the installation of temporary transfer beams located on each side of the subway columns. The temporary transfer beams would be deep steel members that lift the subway columns by means of load jacks. Load jacks could either be located at the subway columns or at the ends of the temporary transfer beams. Temporary posts and beams would then be installed between the existing PSNY beams to support the subway track slab. Once the subway loads were transferred to the temporary supports, the existing PSNY beams, girders, and the column being relocated could be removed and replaced with new PSNY beams supported on new girders and columns. Final load transfer would be achieved when the subway structure loads are transferred from the temporary supports to the permanent new PSNY structure.

Option A has the largest impact to the 8th Avenue Subway as the temporary supports would be located within the NYCT tunnel. The installation of these temporary members would also require being in the right of way and punching through the subway track slab.



Source: Developed for the PCIP Study based on drawings obtained from NYCT Archives.

Figure 24: Section Cut of 8th Avenue Subway and PSNY.

Option B: Load transfer within PSNY structure (modified support location)

This option reduces the impact to the 8th Avenue Subway by containing the load transfer within the PSNY space. Temporary support posts would be installed directly beneath the PSNY girders where the existing beams connect to support the 8th Avenue structure. With the load transferred to the temporary structure, the existing column and segments of the girder between the beams would be removed to allow new permanent beams to span to permanent girders and columns on the new platform and between tracks. Final load transfer would be achieved when the subway structure loads were transferred to the new permanent beams from the temporary supports which could then be removed.

There are several significant challenges involved with this option. First, the existing beams are closely spaced which significantly limits the area available to install the new beams. Second, due to the space constraints, it would be difficult to achieve a positive contact between the track slab and the new beams. Due to this condition, the track slab could deflect more in some areas which could cause undesired cracks requiring further investigation and repair.

Option C: Load transfer within PSNY structure (maintain support location)

Lastly, Option C considers transferring the subway load by providing temporary posts under the PSNY beams directly under the subway columns. With the subway column supported, the PSNY beam would be partially removed to allow installation of reinforcing plates under the track slab. The reinforcing plates would strengthen the track slab for the concentrated load at the subway column line. Temporary supports would then be provided under the reinforcing plates and in between the PSNY beams to support the column loads and track slab. Once load is supported on temporary structure, the PSNY beams, girders, and columns could be removed and a new permanent beam would span to new girders and columns on the extended platform and between tracks.

The existing space constraints are also a main challenge in this option. This option also requires additional steps to reinforce the track slab at the column line. However, doing so allows for the new permanent beams to be placed where the existing beams were located which would mitigate some of the concerns of Option B. In addition, transferring the load within the PSNY structure while maintaining the support location is expected to minimize impacts on the 8th Avenue Subway.

The above options were developed as preliminary concepts to demonstrate initial feasibility and provide a potential approach to transfer the load and relocate the impacted columns. Further investigation of the existing structural framing, foundation, ground conditions, clearances, and required utility relocation would be necessary to advance these concepts and prove their viability. The three options described each have their own advantages, disadvantages, and risks. Developing these concepts in the next stage would allow feasibility to be confirmed, several challenges to be resolved, and one preferred sequence to be selected.

6.6.4.1.2 Potential Impact to 9th Avenue Columns

The proposed design of the westward extension of Platforms 1 and 2 (Alt 14) would not require the relocation of any of the columns that support 9th Avenue. However, one of the track alignments that was developed and not further advanced (Option 3) impacted a significant number of these columns and therefore the following is a brief description of the impact and challenges involved with the relocation of these columns.

The track realignment proposed for this non-preferred alternative would require the relocation of approximately 28 columns that support the bridge of 9th Avenue. Based on the close spacing of the existing PSNY track columns, it is assumed that the existing framing supporting the station ceiling and the street above is heavily loaded. If the clearance above the track to the existing structural frame is limited, then the proposed reframing associated with the column relocation would have to fit within the same structural depth. The proposed track realignment allows for the columns to be relocated to the south of the existing column locations. This would increase the framing span which would also increase the structure member depth. Further study and investigation would be required to determine existing clearances, framing, loads, proposed structural spans and depth, as well as to verify feasibility.

Conceptually, construction for the column relocation would require temporary supports and jacking to allow the existing columns to be removed. Due to the proximity of other existing tracks, the temporary supports would likely impact these tracks. In addition, the removal and relocation of these columns would likely require removing lanes from service on 9th Avenue, which has very heavy traffic, while columns are relocated. This effort could potentially be sequenced to allow for partial street closures and would have to be closely coordinated with NYC DOT to minimize impacts.

The relocation of the columns supporting 9th Avenue, while potentially feasible, would introduce considerable challenges and risks and would significantly increase the operational impact on both PSNY and on 9th Avenue. Therefore, the alternative selected to extend Platforms 1 and 2 to the west avoids the relocation of these columns.

6.6.4.1.3 Relocation of Impacted Columns

In addition to the impacted columns under 8th Avenue, there are a significant number of other PSNY columns that would require relocation. A plan and a list of the impacted columns are included as part of the Structural Appendix. Although these columns are generally spaced further apart, this preliminary review has determined that the construction approach to relocate them would be like that proposed for relocating the columns supporting the 8th Avenue Subway. Temporary supports and jacking would be required, and further investigation needed to develop the proposed reframing and identify any potential issues or areas of concern. Relative beam depths could be inferred based on current column spacing (larger spans indicate deeper beams) but more information is needed on existing frame, columns, foundation, ground condition, and clearances.

6.6.4.1.4 Other Considerations

Additional considerations include adjustments to NYCT track outage times, possibly having to conduct work in constrained spaces, and relocation of existing conduits, utilities and electrical, mechanical, fire safety and power equipment.

6.6.4.2 Potential Implications on Operations and Maintenance Cost

The most significant implications on these costs are summarized below. However, comprehensive financial analysis by NJ TRANSIT would be required to develop a detailed O&M cost estimate as part of a future study. This is needed to properly assess and qualitatively estimate and evaluate these costs once preliminary engineering information is available. These include:

- Higher O&M costs related to security, cleaning and passenger information system maintenance due to the proposed extension of existing concourses.
- Minor decrease in O&M costs associated with the removal of tracks at "E" and "D" Yards.
- Potential minor decrease on the O&M costs due to the removal of multiple double slip switches on the "U" and "M" Ladders. While this alternative proposes installing additional turnouts, the maintenance cost of these is expected to be lower than the existing double slip switches. In total, this alternative would remove nine existing turnouts and nine existing double slip switches while installing 17 new turnouts and one double slip switch.
- No change in Rail Operations supervision and Maintenance of Equipment (Mechanical) support needs as the platform extensions will not alter the number of NJ TRANSIT train movements.

6.6.4.3 Potential Implementation Phasing and Service Impacts

This alternative proposes substantial modifications to the existing PSNY track layout and would require significant service outages from NJ TRANSIT, NYCT, and Amtrak. While service outages on Tracks 1, 2 and 3 would be considerable and extensive, it is expected that the impact to the rest of the station and 8th Avenue Subway tracks could potentially be limited to weekend outages.

A suggested conceptual track staging plan is described below. However, comprehensive construction staging coordination with the Operations, Structural, Architectural, Communications, Signals and Electric Traction/Catenary disciplines would be required to develop a detail staging plan during preliminary engineering to minimize impacts to operations.

Stage 1 (weekdays): Partial demolition of the Diagonal Platform and relocation of relevant impacted columns. Minimal impact to existing operations would be expected.

Stage 2 (weekdays): Partial installation of "R" and "T" Ladders including double slip switches, turnouts and sections of future Tracks 2 and 3 that would not impact existing operations and that would not require outages on platform tracks. Minimal impact to existing operations would be expected.

Stage 3 (weekdays): Removal of Track 3E, reconfiguration of "E" Yard and installation of the west section of the Platform 1 extension that would not impact Track 1. Impact to tracks would be limited to "E" Yard. Track 3E would no longer be in service.

Stage 4 (weekdays): Removal of Tracks 3D and 4D and relocation of relevant impacted columns. The double slip switch connecting Track 4D to the "M" Ladder would be removed, and a new turnout would be installed during weekend outages. Tracks 3D and 4D would no longer be in service.

Stage 5 (weekdays): Removal of Track 5D and installation of "R" Ladder and connections to Tracks 5D and 4D. Partial installation of "T" Ladder. The double slip switch connecting Track 5D to the "M" Ladder would be removed, and a new turnout would be installed during weekend outages. Track 5D would no longer be in service.

Up to this stage, access would be provided to all platform tracks and impacts to the "M" and "U" Ladders would be anticipated to be limited to weekend outages.

Stage 6 (weekdays): Extension of Track 1 and completion of Platform 1 extension. Track 1 would be taken out of service. Weekend outages would be required for Track 2 and the south most section of the "M" Ladder.

Stage 7 (weekdays): Connection of Track 1 to "R" Ladder and "E" Yard. Impact to tracks would be limited to "E" Yard and Track 1 would remain out of service.

Stage 8 (weekend outages): Removal of Track 5A, connection of "R" Ladder to Track 1X and relocation of relevant impacted columns. The new turnout on the "M" Ladder providing connection to the "T" Ladder would also be installed. Weekend outages would be required for Tracks 5A, 6D, 1X and the "U" and "M" Ladders. Double slip switches connecting Track 5A to the "U" and "M" Ladders would be removed, and new turnouts would be installed during weekend outages. Track 5A would no longer be in service.

After the completion of this stage, Track 1 would be back in service and it is expected that up to this stage impacts to Tracks 2-4 could be limited to weekend outages.

Stage 9 (weekdays): Extension of Track 2 and installation of associated connections to "T" and "R" Ladders. Track 2 would be taken out of service until the completion of this stage. Weekend outages would be required for the south most section of the "U" and "M" Ladders.

After the completion of this stage, Track 2 would be back in service.

Stage 10 (nights and weekend outages): Relocation of Columns supporting 8th Avenue Subway and 8th Avenue. Night and weekend outages would be required on Tracks 2 and 3 and in the 8th Avenue Subway Tracks.

Stage 11 (weekdays): Extension of Platform 2, Track 3 and installation of associated connection to "T" Ladders. Track 3 would be taken out of service until the construction completion of this stage. Weekend outages would be required for Tracks 2 and 4 and the south most section of the "U" and "M" Ladders.

After the completion of this stage, Track 3 would be back in service.

Stage 12 (weekdays): Extension of Track 4 and installation of associated connection to the "M" Ladder. Track 4 would be taken out of service until the construction completion of this stage. Weekend outages would be required for Track 5 and the south most section of the "U" and "M" Ladders.

After the completion of this stage, Track 4 would be back in service.

6.6.4.4 Conceptual Cost, Schedule and Qualitative Risk Considerations

The order-of-magnitude cost estimate, includes $34.6 Million (unescalated) provision for soft costs and a 40% ($66.1 Million, unescalated) unallocated contingency. The total order-of magnitude cost estimate for Alt 14, including the projected escalation to midpoint of construction for this alternative, exclusive of costs associated with real estate acquisition, buildings demolition and underpinning, rolling stock costs and finance costs and including contingency, is $251.8 Million. This estimate, which was developed following the format required by FTA (SCC categories 10 thru 90), is consistent with AACE International (Association for the Advancement of Costs Engineering) best practices and is considered a Class 5 estimate.

The conceptual schedule estimates the total duration of this project on 1,276 days, approximately 4.9 years, including planning, design, and construction. The major risks are the design challenges due to the existing spatial constraints, the relocation of the 8th Avenue Subway Columns as well as numerous PSNY columns, the operation impacts during construction and the usual design, construction, budget and schedule risks associated with a project at this location and of this scale. For additional details on the conceptual cost estimate, schedule and the qualitative overview of the main risk considerations, refer to Appendix C.

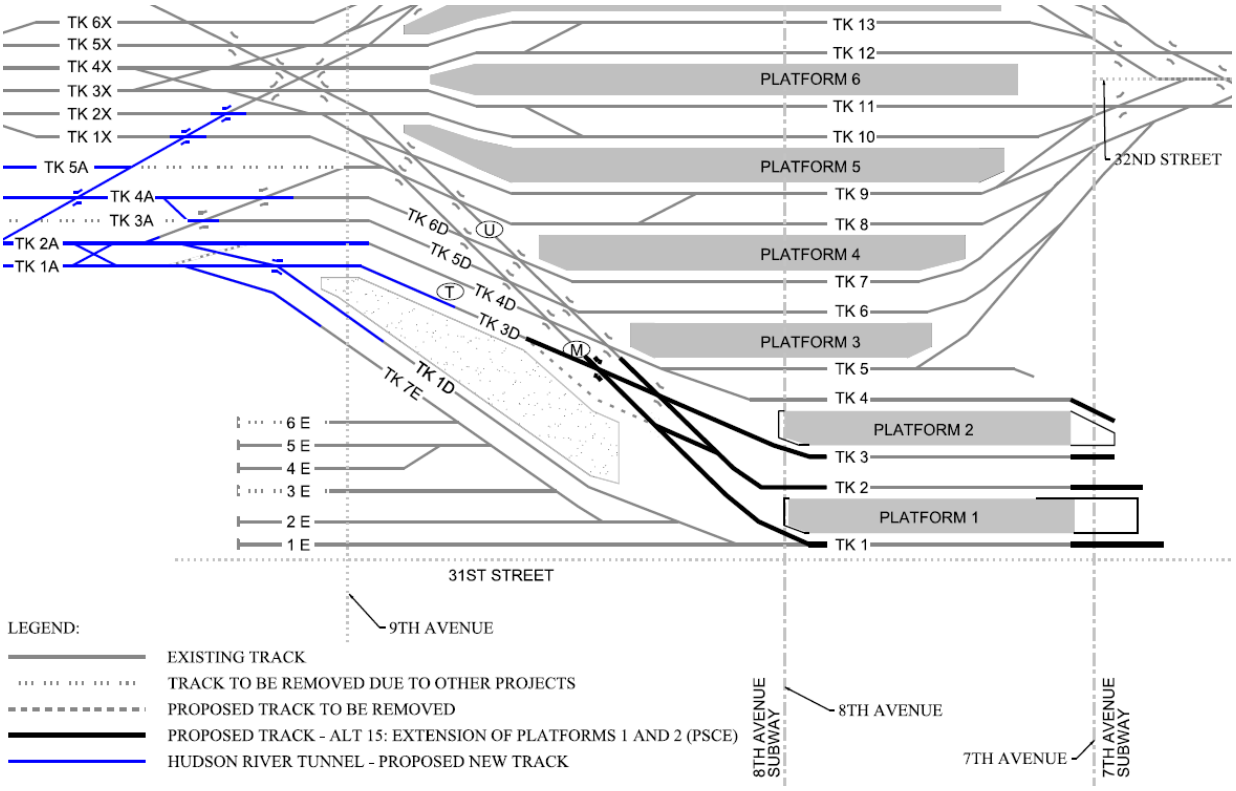
6.7 Alt 15: PSCE – Eastern and Western Extension of Tracks 1-4

6.7.1 Alternative Description

Proposed Alt 15 would extend Platforms 1 and 2 to the west to provide new vertical connections to the West End Concourse and to the east into the 11 Penn Plaza Building basement, where a new connection would be provided to both 7th Avenue street level and the 7th Avenue Subway. These improvements would allow 11-car train consists (10 car plus locomotive) to use Platforms 1 and 2 which would improve overall capacity at PSNY by providing additional seat capacity trans-Hudson and greater flexibility for platforms

assignments and reducing operational conflicts. For reference, the two existing platforms evaluated for extension can only accommodate 9-car train consists.

The proposed track schematic for Alt 15 is shown in Figure 25. The approximate locations of the streets and NYCT subway lines are also included for reference. Conceptual track design for this alternative are included in Appendix A.



Source: Developed for the PCIP Study.

Figure 25: Alt 15 Proposed Track Schematic.

On the west, Alt 15 proposes to reconfigure the south section of the "U" and "M" Ladders and the west section of Tracks 1-4 to slightly extend Platforms 1 and 2 and connect them via an enclosed walkway with 4.4 ft-wide stairs to an extension of the West End Concourse. In addition, this alternative would provide a new service stair to connect the proposed extension of the West End Concourse to a clear area at the track level which would facilitate the access to the Diagonal Platform. In the past, Amtrak had raised concerns with the proposed reconfiguration of the "U" and "M" Ladder as it required the use of reverse curves on the west end of Tracks 1-4 which could potentially increase risk of derailments.

The proposed eastern modifications would require the demolition of a section of the east retaining wall, underpinning and tunneling under the 7th Avenue Subway structure and the relocation of the Signal Power Equipment at the eastern end of Platforms 1 and 2. These improvements would allow the extension of Platforms 1 and 2 to the east through the original 1909 Pennsylvania Railroad, now Amtrak, easement area provided at the southeastern corner of

7th Avenue and 31st Street. This easement area lies below the subsequently constructed (1924) 11 Penn Plaza Building. These would support the extension of Tracks 1, 2, 3 and 4 by approximately 83 ft, 132 ft, 203 ft and 193 ft respectively. In addition, a new north-south corridor would be provided to connect the new end of Platforms 1 and 2 to 7th Avenue street level and the 7th Avenue Subway via one new stair and a new escalator. The alternative would not install any new elevators.

6.7.2 Additional Considerations

The design for Alt 15 was not developed as part of this project and it is shown for reference and comparison purposes only. The design files were obtained on September 2018 from NJ TRANSIT and were developed as part of the Penn Station Capacity Enhancement Project (PSCE) 30% design submission. The conceptual drawings showing this alternative are included in Appendix A. For additional information regarding this design, refer to the PSCE 30% design documentation which was used without modification in the PCIP study.

6.7.2.1 Potential Implications on Operations and Maintenance Cost

The modifications proposed by this alternative are not expected to have a considerable impact to the current overall Operations and Maintenance (O&M) budget. The most significant implications on these costs are summarized below. However, NJ TRANSIT would need to be consulted, as part of a future study, regarding financial analysis to properly estimate and evaluate changes to annual O&M costs with likely changes being:

- Slightly higher O&M costs due to increased security and cleaning associated with the proposed Platforms 1 and 2 as well as the new connection to the 7th Avenue Subway and the West End Concourse.
- Additional security and cleaning costs associated with the long passageway through 11 Penn Plaza Building.
- No changes to Rail Operations supervision or Maintenance of Way (Mechanical) personnel are anticipated because the number of trains operating will not change with this alternative.

6.7.2.2 Conceptual Cost, Schedule and Qualitative Risk Considerations

The order-of-magnitude cost estimate, includes $43.1 Million (unescalated) provision for soft costs and a 25% ($51.5 Million, unescalated) unallocated contingency. The total order-of magnitude cost estimate for Alt 15, including the projected escalation to midpoint of construction for this alternative, exclusive of costs associated with real estate acquisition, buildings demolition and underpinning, rolling stock costs and finance costs and including contingency, is $278.0 Million. This estimate, which was developed following the format required by FTA (SCC categories 10 thru 90), is consistent with AACE International (Association for the Advancement of Costs Engineering) best practices and is considered a

Class 4 estimate since it is based on the cost estimate developed for the PSCE 30% Design. The team updated the PSCE 30% cost estimate to 2019 dollars.

The conceptual schedule estimates the total duration of this project as 1,143 days or approximately 4.4 years, including final design, and construction. The conceptual cost and schedule estimates are based on those developed for the PSCE 30% Design. The major risks for this alternative are the design challenges due to the existing spatial constraints, the underpinning of the 7th Avenue Subway, the impact and permits required for the work related to the 11 Penn Plaza Building, the partial removal of the east retaining wall and the usual design, construction, budget and schedule risks associated with a project at this location and of this scale. For additional details on the conceptual cost estimate, schedule and the qualitative overview of the main risk considerations, refer to Appendix C.

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7 Development of Selected Operations Alternatives (Task 4B)

7.1 Alt OP1: 18-Minute Revenue-To-Revenue Dwell Time Concept

7.1.1 Alternative Description

This alternative is focused on NJ TRANSIT scheduling and operating changes to peak period revenue-to-revenue train "turns" at Penn Station, reducing the minimum scheduled value from 22 minutes to 18 minutes. While a small number of peak train turns are scheduled for less than 22 minutes today, these are limited to special cases where the reverse peak train has low ridership, and/or the train consist is short. Because the number of platforms available to NJ TRANSIT at Penn Station is limited, a reduced minimum scheduled turn time could translate into capacity gains, provided that the higher station capacity is not also constrained by tunnel capacity limitations. This alternative would have no effect on revenue to non-revenue turns, to non-revenue to revenue turns or to trains that loop via Sunnyside Yard.

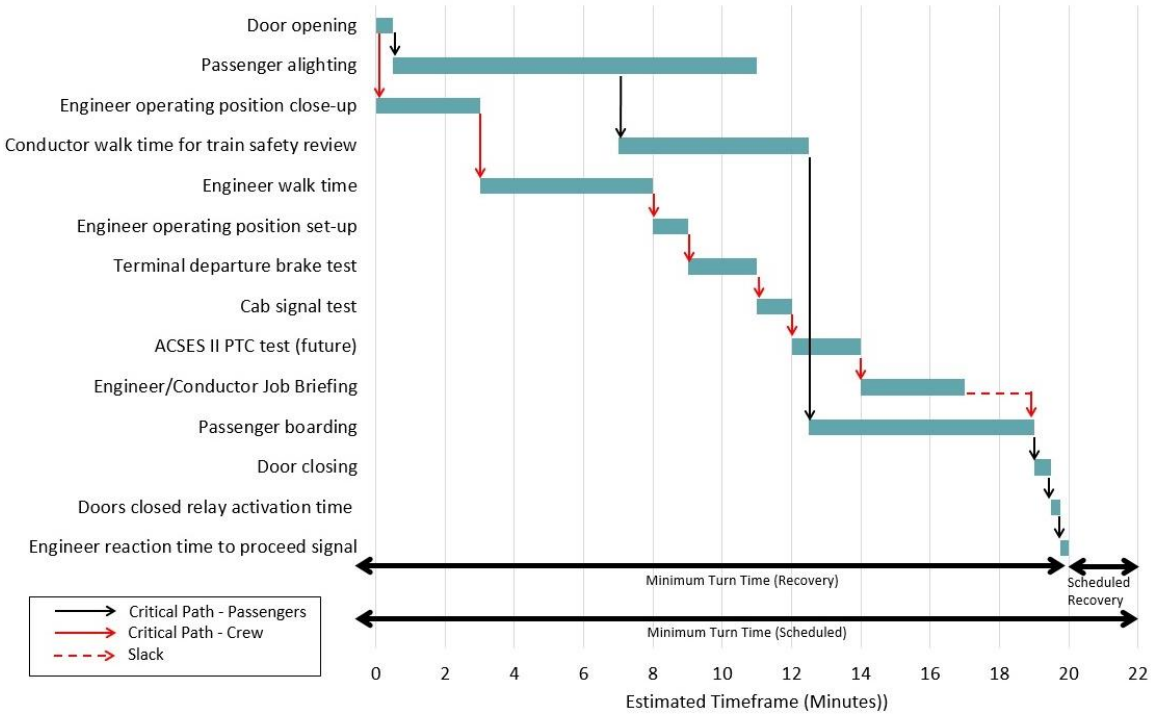
7.1.2 Operations Analysis

This work began with a detailed timing of Penn Station dwell times for peak period train turns with high bidirectional ridership. This result first in the existing 22-minute future baseline dwell time model shown in Figure 26. This reflects current dwell time component timings plus the required time for PTC initialization for westbound trips.

After discussion with NJ TRANSIT Rail Operations and Service Planning, it was agreed that an 18-minute minimum revenue to revenue turn time could be evaluated as part of PCIP. This change would require the use of "drop-back" or "fall-back" crews to speed turn times and eliminate the need for engineers to walk the length of the train. The associated dwell time model is shown in Figure 27.

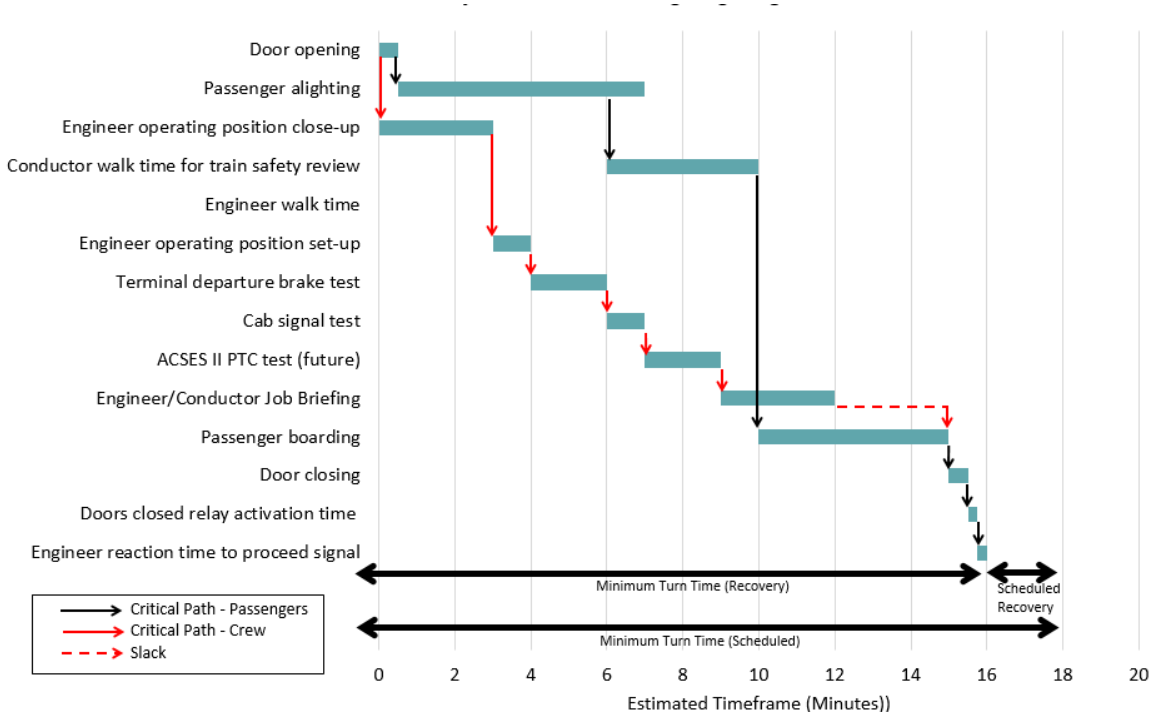
LTK utilized its Penn Station Track Assignment Utility, first developed for the Penn Station Operations Study, to evaluate associated throughput gains from a station track capacity perspective. Using the utility, all NJ TRANSIT trips were assumed to maintain their existing inbound and outbound timings but were re-paired to achieve the minimum possible dwell times greater than 18 minutes. Trips without a paired trip were sent to Sunnyside Yard. For planning purposes, no constraints on trip-specific equipment types assumed. Existing Amtrak Empire Corridor and LIRR levels of service and track utilization were maintained in all analyses.

LTK then added additional trips if necessary to reach 24 TPH and 26 TPH target levels (including Amtrak trains) in the North River Tunnels during the peak period of 7:00 am to 9:00 am. Each added station occupancy was a revenue to revenue turn with eastbound and westbound trips and these trips were added based on North River Tunnel slot availability. The resultant NRT headways are 2 minutes or greater at all times.



Source: Developed for the PCIP Study.

Figure 26: PCIP Dwell Time Analysis - Future Baseline.



Source: Developed for the PCIP Study.

Figure 27: PCIP Dwell Time Analysis - Future Baseline with Dropback Crew, No Adjacent Track Boarding/ Alighting.

Table 7 presents the results of the analysis. With a single inbound trans-Hudson track feeding trains to Penn Station, the Alt OP1 dwell time criteria would allow the current 24 TPH inbound Amtrak/NJ TRANSIT volume and the ability to maintain one spare maximum length track (such as Track 10) for enhanced reliability. This is not possible today with minimum 22-minute revenue to revenue turns. At a 26 TPH train volume, the new Alt OP1 dwell times will support this volume on existing station tracks but without a spare track for operational flexibility.

With the NRT and HRT in service, the maximum practical capacity of existing Penn Station with the Alt OP1 dwells was found to be 30 TPH (with minimum 5-minute temporal alighting separation between arriving trains on two sides of island platforms) and 32 TPH (no minimum required temporal alighting separation). Three-minute minimum headways were observed on each of the two inbound tunnels in the NRT and HRT analysis. Table 7 considers both trans-Hudson tunnel capacity and platform capacity to show combined Terminal Capacity.

Scenario	Terminal Capacity w. Temporal Alighting Limits	Terminal Capacity w/o Temporal Alighting Limits	Spare Track Available for Flexibility?
Single Inbound NRT Track – 24 TPH	24	24	Yes
Single Inbound NRT Track – 26 TPH	26	26	No
Dual Inbound NRT Tracks – Variable Headways	30	32	No

Source: Developed for the PCIP Study.

Table 7: Existing PSNY Track Capacity with 18 Minute Revenue-to-Revenue Turn Times.

7.1.3 Potential Implications on Operations and Maintenance Cost

Alt OP1 would have a significant increase in NJ TRANSIT O&M costs because of the need to support fall-back or drop-back crews during both morning and evening peak periods. This would increase the number of on-duty crews required to operate a given level of service, increasing labor, fringe, overhead and supervisory costs. With NJ TRANSIT taking advantage of increased capacity through this alternative, O&M costs would increase due to vehicle maintenance, Amtrak electric traction costs, Amtrak track maintenance costs, and other Amtrak NEC operating costs.

7.1.4 Potential Implementation Phasing and Service Impacts

Implementation phasing considerations are limited to training and deploying additional Train Engineers, Train Conductors, Transportation Supervisors, and Maintenance of Equipment (Mechanical) personnel. There would be some wait time for implementation due to the need to recruit, hire and train additional operating personnel. There would be no implementation-related service impacts during the wait time for this alternative.

7.1.5 Qualitative Risk Considerations

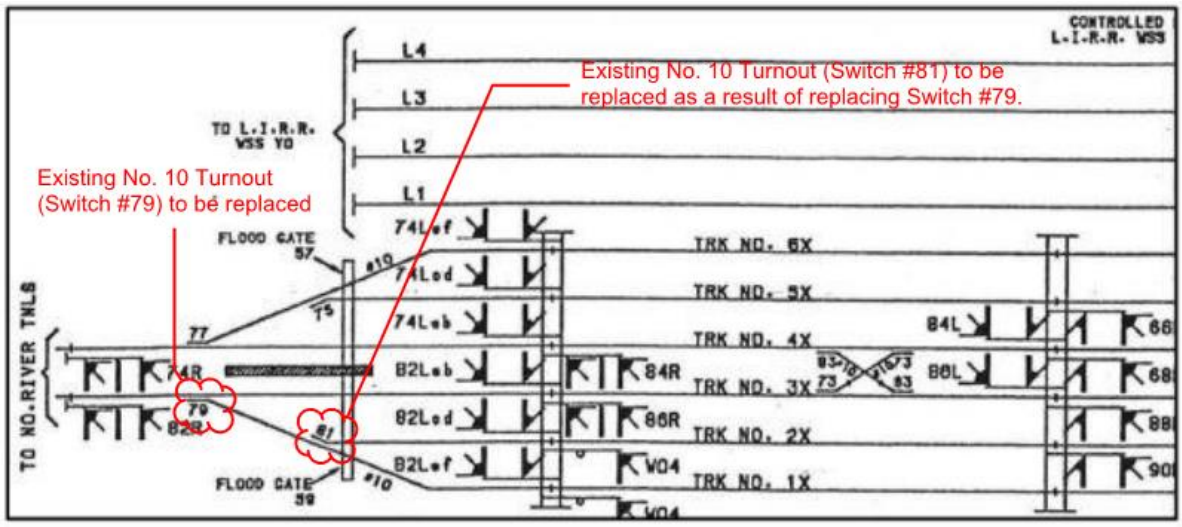
The major risks identified for this alternative are the near- and long-term impacts on current operations procedures and operations and maintenance costs, potential concerns that NJ TRANSIT and Amtrak operating personnel may have on delivering this improved operational efficiency, and the potential need for improvements to existing PSNY facilities that may be required to support the increased personnel activities to support the reduction of the revenue-to-revenue train dwell time. For additional details on the qualitative overview of the main risk considerations, refer to Appendix C.

7.2 Alt OP2: X-Tracks Improvements Concept

7.2.1 Alternative Description

This alternative, which can be paired with Alt OP1 or implemented independently, upgrades a critical switch approaching Penn Station from New Jersey to 30 MPH geometry, which would be a significant improvement over its current 15 MPH maximum diverging speed. This switch, "A" Interlocking Switch 79, would allow arriving trains to alternate between Tracks 3X and 1X at 30 MPH. Such a change would allow trains to enter the tracks at 30 MPH, rather than being enforced at the current 15 MPH speed.

Figure 28 shows a partial track schematic of PSNY and highlights Switch (No.10 turnout) proposed to be upgraded. Conceptual track design drawings are included in Appendix A.



Source: PSNY track schematic obtained from previous project and modified for the PCIP Study.

Figure 28: Alt OP2 X-Tracks Improvements Concept.

Previous simulation studies going back to the 1986 Amtrak/NJ TRANSIT High Density Interlocking System (HDIS) design have shown that this change, coupled with a dispatch strategy that approximately alternates eastbound trains between Tracks 3X and 1X, increases tunnel throughput by approximately 2 TPH. As noted in the previous section, this

improvement could be coupled with the current 22-minute minimum revenue-to-revenue turn times for capacity gain (but no spare station track) or with the Alt OP1 18 minute minimum revenue-to-revenue turn for capacity gain (with spare station track).

Alt OP2 requires delivery of some difficult infrastructure improvements. First, ACSES II PTC coverage must be extended to the normally eastbound X tracks – 1X, 2X and 3X. This does not include the "U" and "M" Ladders. Without the eastward PTC extension, the ACSES cab signal system must enforce all train movements to 15 MPH prior to passing Switch 79. Second, the close sidewall clearance of Switch 79 may require mitigation should it be replaced with No. 12 or No. 15 geometry. Both designs are shown in the appendix of this report.

It should be noted that, because of the reverse curve geometry, Switch 81 (which defines the facing point split between 1X and 2X) must also be upgraded. Though 30 MPH geometry to Track 2X is not required and the current alignment of Switch 81 is straight to Track 1X, the reverse curve geometry here does require replacement of Switch 81. Both designs in the appendix of the report reflect this design consideration.

7.2.2 Operations Analysis

No operational analysis was performed for this alternative. Though the capacity benefits of this improvement were well-documented in the late 1980s, an update to this analysis is warranted. Such analysis would require rail operations network simulation, which is outside of the base scope of this study.

7.2.3 Track Design

The existing close sidewall clearance at Switch 79 may require mitigation through structural modifications should it be replaced with No. 12 or No. 15 geometry. This modification has been cited as one of the reasons that the 1980s recommendation for this improvement was not approved by Amtrak Engineering at the time.

Because of the reverse curve geometry, Switch 81 (which defines the facing point split between 1X and 2X) must also be upgraded. Though 30 MPH geometry to Track 2X is not required and the current alignment of Switch 81 is straight to Track 1X, the reverse curve geometry here does require replacement of Switch 81. Both designs in the Appendix A of the report reflect this design consideration.

7.2.4 Potential Implications on Operations and Maintenance Cost

This improvement would require additional Amtrak O&M resources which would be borne NJ TRANSIT as part of the NEC cost allocation methodology. This includes:

- Additional ACSES PTC II maintenance resources due to slightly expanded coverage area in a congested terminal,
- Additional track maintenance resources due to a higher FRA class of track within the "X" Tracks area.

7.2.5 Potential Implementation Phasing and Service Impacts

Implementation phasing considerations are limited to training and deploying additional Train Engineers, Train Conductors, Transportation Supervisors, and Maintenance of Equipment (Mechanical) personnel. There would be some wait time for implementation due to the need to recruit, hire and train additional operating personnel. There would be no implementation-related service impacts during the wait time for this alternative.

7.2.6 Qualitative Risk Considerations

The major risks are obtaining the required approvals from Amtrak, including their concurrence on installing non-standard turnouts, the design challenges due to the existing spatial constraints, the potential impact to the NRT Portal, the risk to significantly impact operations during construction, and the usual design, construction, budget and schedule risks associated with a project at this critical location and of this scale. For additional details on the qualitative overview of the main risk considerations, refer to Appendix C.

8 Alternatives Evaluation, Selection and Next Steps (Task 5)

8.1 Evaluation of Alternative Concepts

This chapter documents the alternatives comparison and evaluation performed on the four infrastructure alternatives and the two operational alternatives that were advanced based on the preliminary development and evaluation of alternatives discussed in Chapter 1 of this report. This is Phase 2 of the evaluation process and will focus only on the advanced alternatives which were developed to a level of detail sufficient to qualitatively estimate the potential passenger and train capacity benefits, to define the general infrastructure configuration, and to confirm feasibility of construction. The goal of this effort was to evaluate and assess competing alternatives in an objective manner following the approach and the criteria developed under Task 3: "Approach to Alternatives Development and Alternatives Evaluation" that is documented in Chapter 4 of this report.

As initially anticipated, some of the shortlisted alternatives are not necessarily comparable against one another. Therefore, infrastructure alternatives that proposed similar concepts were evaluated against each other. That is, Alt 12 was compared to Alt 13 since they both propose building a new platform under 31st Street and Block 780, and Alt 14 was compared to Alt 15 since they both propose extending Platforms 1 and 2 to increase the length of trains that can be fully platformed. The two operations alternatives were evaluated against each other; however, these two alternatives are not mutually exclusive, and both could be potentially advanced as both would provide value and be beneficial in different ways.

This section provides a comparison of the infrastructure alternatives evaluated and describes the methodology and the results of the parallel moves analysis performed on the infrastructure alternatives. This section also documents the evaluation of alternatives and presents the evaluation results obtained.

8.1.1 Infrastructure Alternatives Comparison

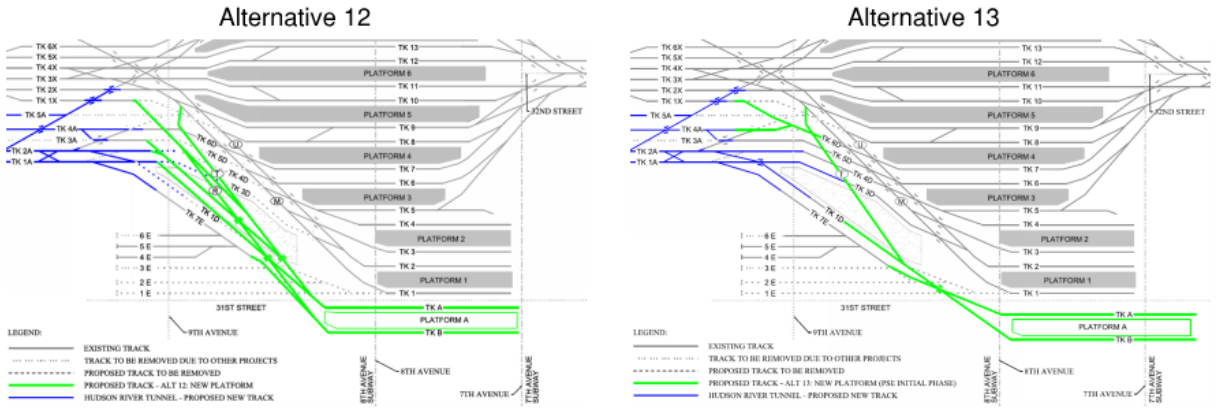
The four infrastructure alternatives considered were discussed in detail in previous chapters of this report. Nevertheless, since some of these alternatives are conceptually very similar, the two tables below provide a high-level summary of the four infrastructure alternatives, facilitating the comparison of alternatives and highlighting some of their main design differences. The infrastructure alternatives compared are Alt 12 and 13, and Alt 14 and 15. These comparison of these two groups of alternatives is summarized in Table 8 and Figure 29 and Table 9 and Figure 30 respectively.

Alt 12	Alt 13
PCIP – New platform under 31st Street and Block 780.	Initial phase of Amtrak Penn Station Expansion Project – New platform
Brief Description	
• New "T" and "R" Ladders providing access to a new island platform south of Platform 1. • New concourse and associated pedestrian connection improvements.	• New "T" and Ladder providing access to a new island platform south of Platform 1. • New concourse and associated pedestrian connection improvements.
Track Comparison	
• New "T" and "R" Ladders provide access to both the NRT and the planned HRT. • New ladders support parallel moves. • Partial removal of Tracks 5A, 3D, 4D and 5D. • New track connections to Tracks 3D, 4D and 5D. • Extended closure of Track 1. • Significant reduction of "E" Yards storage capacity and removal of Tracks 1E, 2E and 3E	• New "T" Ladder provides access to both the existing NRT and the planned HRT. • New ladder does not support parallel moves. • Removal of Tracks 5A and 3D. • Significant reduction of "E" Yards storage capacity and removal of Tracks 1E, 2E and 3E.
Platform Comparison	
• New 1020 ft platform south of Track 1. • Platform generally aligns with existing PSNY platforms (east/west). • Platform location avoids impact to Block 806, but it results in greater impact on Block 754. • Platform connects with the West End Concourse.	• New 1090 ft platform south of Track 1. • Platform offset east from existing PSNY platforms. • Platform extends below 7th Avenue and 7th Avenue Subway. • Platform location impacts Block 754, 780 and 806. • Platform does not connect with the West End Concourse.
Concourse Comparison	
• New concourse proposed above Platform A. • Concourse A connects with the Exit Concourse, the planned extension of the Central Concourse and the NJ TRANSIT East End Concourse providing good east-west connectivity and improving overall PSNY passenger flow. • The West End Concourse would be extended south to provide egress capacity access from Platform A.	• The Exit Concourse, the planned extension of the Central Concourse and the NJ TRANSIT East End Concourse would be extended over the new platform to provide passenger vertical connections. • Reduced size concourse providing east-west connectivity. • Provides access east of 7th Avenue.

Alt 12	Alt 13
PCIP – New platform under 31st Street and Block 780.	Initial phase of Amtrak Penn Station Expansion Project – New platform
Vertical Circulation Comparison	
• Eight stairs from platform to Concourse A. • Six escalators from platform to Concourse A. • Four elevators from platform to Concourse A. • Four stairs from Concourse A to street level. • One stair from the West End Concourse to Moynihan Train Hall.	• Four stairs from platform to concourse. • Two escalators from platform to concourse. • One elevator from platform to concourse. • One elevator from concourse to street level. • It is anticipated that additional vertical circulation from the concourse level to the street level would be provided.
Structural Comparison	
• Underpinning required for building on Block 780 and 754. Trade-off analysis would be performed to evaluate and determine the buildings that would be underpinned and demolished. • Underpinning of the Amtrak Service Building. • Reduced area of buildings that require underpinning. • Underpinning of 8th Avenue Subway. • Relocation of 39 columns within the station footprint required. • Complete removal of the retaining wall. • Removal of a significant section of the Diagonal Platform. • Provides different areas for location of foundations and columns of the potential development of the parking lot located on the south west corner of 31st Street and 7th Avenue (Block 754, Lot 44).	• Underpinning required for building on Block 780, 754 and 806. Trade-off analysis would be performed to evaluate and determine the buildings that would be underpinned and demolished. • Underpinning of the historic St. John The Baptist Church and Affinia Hotel. • Underpinning of the Amtrak Service Building. • Underpinning of 7th Avenue Subway and 8th Avenue Subways. • Reduced number of column relocations required. • Partial removal of the retaining wall with platform located south of existing retaining wall. • Provides different areas for location of foundations and columns of the potential development of the parking lot located on the south west corner of 31st Street and 7th Avenue (Block 754, Lot 44).

Source: Developed for the PCIP Study.

Table 8: Alt 12 and 13 Comparison Summary.



Source: Developed for the PCIP Study.

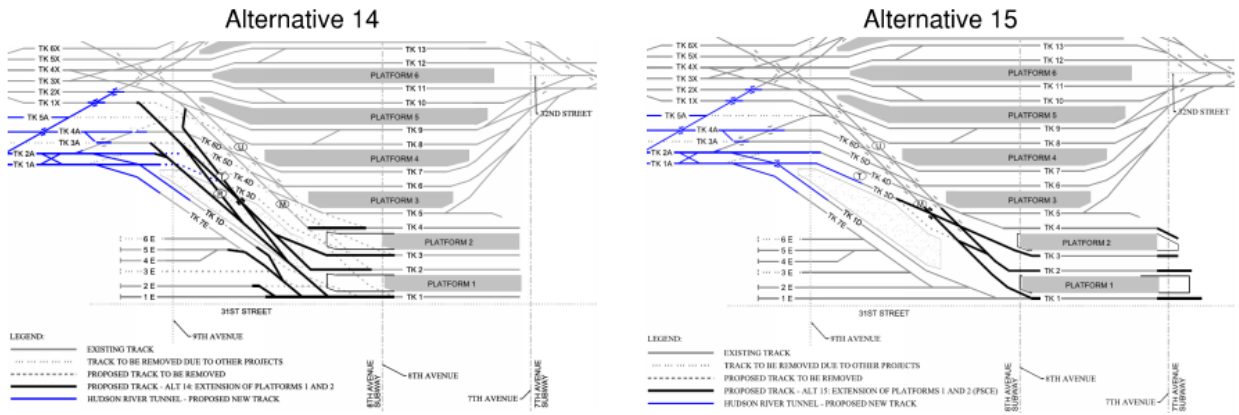
Figure 29: Alt 12 and 13 Track Schematic Comparison.

Alt 14	Alt 15
PCIP – Westward extension of Platforms 1 and 2.	PSCE 30% Design – Eastern and western extension of Tracks 1-4.
Brief Description	
• Disconnect Tracks 1-3 from the "U" and "M" Ladders and connect them to new "T" and "R" Ladders to extend Platforms 1 and 2 to the west and provide new vertical connections to the West End Concourse and the Exit Concourse. • Improvements would allow 12-car train consists to use Platforms 1 and 2.	• Extension of Platforms 1 and 2 to the west to provide new vertical connections to the West End Concourse and to the east into the 11 Penn Plaza Building basement, where a new connection would be provided to both 7th Avenue and the 7th Avenue Subway • Improvements would allow 11-car train consists to use Platforms 1 and 2.
Track Comparison	
• Disconnect Tracks 1-3 from the "U" and "M" Ladders and connect them to new "T" and "R" that provide access to both the existing NRT and the planned HRT. • Maintains equivalent to existing parallel moves capabilities. • Removal of the south section of the "U" and "M" Ladders and partial removal of Tracks 5A, 3D, 4D and 5D. • New track connections to Tracks 4D and 5D. • Reduction of "E" Yards storage capacity and removal of Track 3E.	• Westward extension of Tracks 1-4 into the easement area of the 11 Penn Plaza Building. • Eastern reconfiguration of the "U" and "M" Ladders. • Requires non-compliant distance between reverse curves on the "M" Ladder. • Requires two No. 6 turnouts and a custom No. 7 turnout. • Minimal reduction of "E" Yards storage capacity.

Alt 14	Alt 15
PCIP – Westward extension of Platforms 1 and 2.	PSCE 30% Design – Eastern and western extension of Tracks 1-4.
Platform Comparison	
• Platforms extended west under 8th Avenue Subway and the West End Concourse extension. • No modifications required on the east side of the platforms. • Platforms 1 and 2 would have a total length of 1020 ft. • Platforms 1 and 2 would support 12-car train consists.	• Platforms 1 and 2 extended east under the 7th Avenue Subway and into the 11 Penn Plaza Building. • Platforms are also modified on the west and are slightly extended under 8th Avenue Subway to provide an enclosed walkway to access the West End Concourse. • Platforms 1 and 2 would support 11-car train consists.
Concourse Comparison	
• The West End Concourse would be extended south to provide egress capacity access from Platforms 1 and 2 extensions.	• Small concourse proposed over Platforms 1 and 2 connecting to West End Concourse. • New corridor from Platforms 1 and 2 to provide constrained connection to 7th Avenue and the 7th Avenue Subway.
Vertical Circulation Comparison	
• Two additional stairs from each platform to the West End Concourse. • Additional stair from platform to the Exit Concourse. • New elevator from each platform to the West End Concourse. • Additional stair from West End Concourse extension to Moynihan Train Hall.	• One additional 4.5 ft-wide stair from each platform to the West End Concourse. • Service stair to track level from the West End Concourse extension. • New stair and new escalator to provide access to 7th Avenue and the 7th Avenue Subway. • No new elevators.
Structural Comparison	
• Relocation of 13 columns supporting the 8th Avenue Subway. • Impact to the 8th Avenue Subway track with night and weekend outages. • Relocation of 56 columns (not including columns supporting the 8th Avenue Subway) within the station footprint.	• Relocation of 6 columns supporting the 8th Avenue Subway. • Excavation under and underpinning of the 7th Avenue Subway. • Impact to both the 7th Avenue Subway and the 8th Avenue Subway with night and weekend outages. • Removal of a section of the PSNY east retaining wall.

Source: Developed for the PCIP Study.

Table 9: Alt 14 and 15 Comparison Summary.



Source: Developed for the PCIP Study.

Figure 30: Alt 14 and 15 Track Schematic Comparison.

8.1.1.1 Parallel Moves Analysis

LTK analyzed the existing Penn Station track layout's New Jersey-focused parallel moves capability and compared it with the two short-medium term improvement alternatives as well as with the two long term improvement alternatives. Parallel move capabilities within the approach throats of major rail terminals promote higher reliability and train capacity by supporting as many simultaneous inbound and outbound movements as possible.

The parallel moves analysis was conducted through visual inspection of the applicable track designs and track schematics. Only parallel movements to/from New Jersey were considered. Though they occur on the west side of Penn Station, LIRR movements to/from West Side Yard were not considered because these are unaffected by any of the PCIP alternatives and because such movements rarely conflict with NJ TRANSIT movements. While it is possible that the current level of service on the Amtrak Empire Connection may be impacted by future planned or potential projects such as New York High Speed Rail or MNR Penn Station Access, movements to/from the Amtrak Empire Connection were not considered because currently they are relatively infrequent, generally limited to less than one train per hour per direction versus more than 20 trains per hour per direction to/from New Jersey. The results of the parallel moves analysis are shown in Figure 31 through Figure 35.

The analysis categorized each combination of:

- Inbound (eastbound) movement from New Jersey to a Penn Station track.
- Outbound (westbound) movement to New Jersey from a Penn Station track.

The pairs of inbound and outbound moves in Figure 31 through Figure 35 were categorized as follows:

- Crossing conflicts (physically impossible), colored pink
- Merging conflicts (physically impossible), colored orange

- Possible parallel moves (not supported by design), colored blue
- Possible parallel moves (supported by design), colored green.

An example of a crossing conflict at existing Penn Station is eastbound NRT-Station Track 9 and Station Track 8-westbound NRT. No matter which paths through the terminal throat are selected by the dispatcher, this combination is a physically-impossible crossing conflict where one train must wait for the other. Similarly, an example of a merging conflict at existing Penn Station is eastbound NRT-Station Track 9 and Station Track 9-westbound NRT. These cannot occur simultaneously because a train cannot be routed to Track 9 while a train is concurrently departing from Track 9.

An example of a parallel move that is supported by the original (currently in-service) Penn Station design is eastbound NRT-Station Track 8 and Station Track 9-westbound NRT. One of the very few theoretically possible parallel moves not supported by the currently in-service Penn Station design is eastbound NRT-Station Track 4 and Station Track 5-westbound NRT. These two routes pass through a common point and conflict. This is shown as a blue box in Figure 31. All of the other boxes to left of the orange diagonal line in Figure 31 are green, indicating that theoretically-possible parallel moves are, in fact, possible. The parallel move percentage is computed by dividing the total green boxes by the sum of green plus blue boxes.

Table 10 summarizes the results of the parallel moves analysis. The existing Penn Station represents something of a "gold standard" with the existing "U" and "M" Ladders supporting almost all of the theoretically-possible parallel moves. Table 10 indicates that 99 percent of theoretically-possible parallel moves are, in fact, supported.

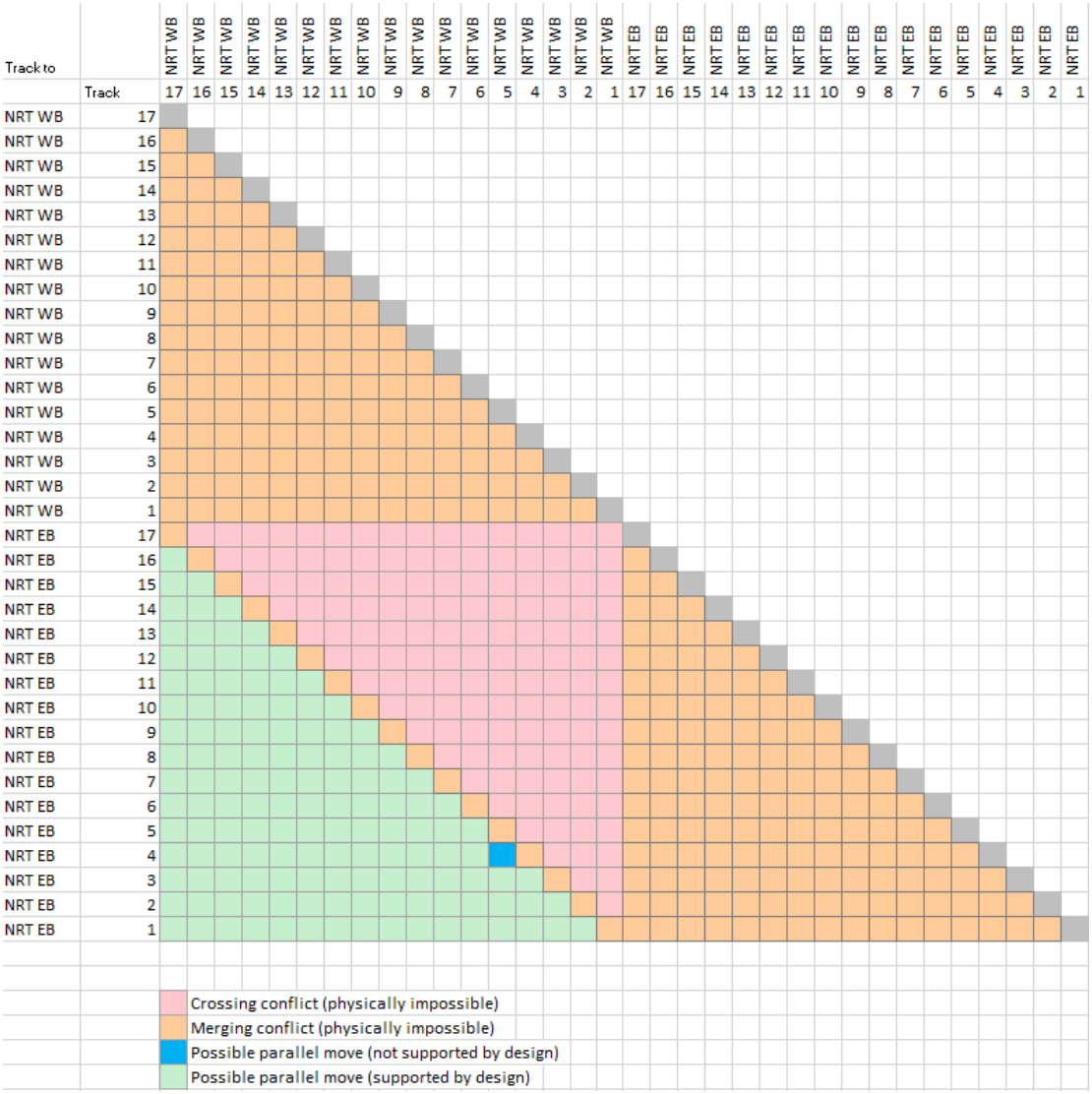
Penn Station Configuration	No. Station Tracks	Supported Parallel Moves Percentage
Existing	21	99%
Alt 12 + 14 ARUP 03-29-2019	23	92%
Alt 13 + 15 ARUP 04-08-2019	23	94%
Alt 12 + 14 + PSE ARUP 03-29-2019	29	86%
Gateway + PSE Amtrak Design Team 05-09-2018	29	89%

Source: Developed for the PCIP Study.

Table 10: Parallel Move Percentages.

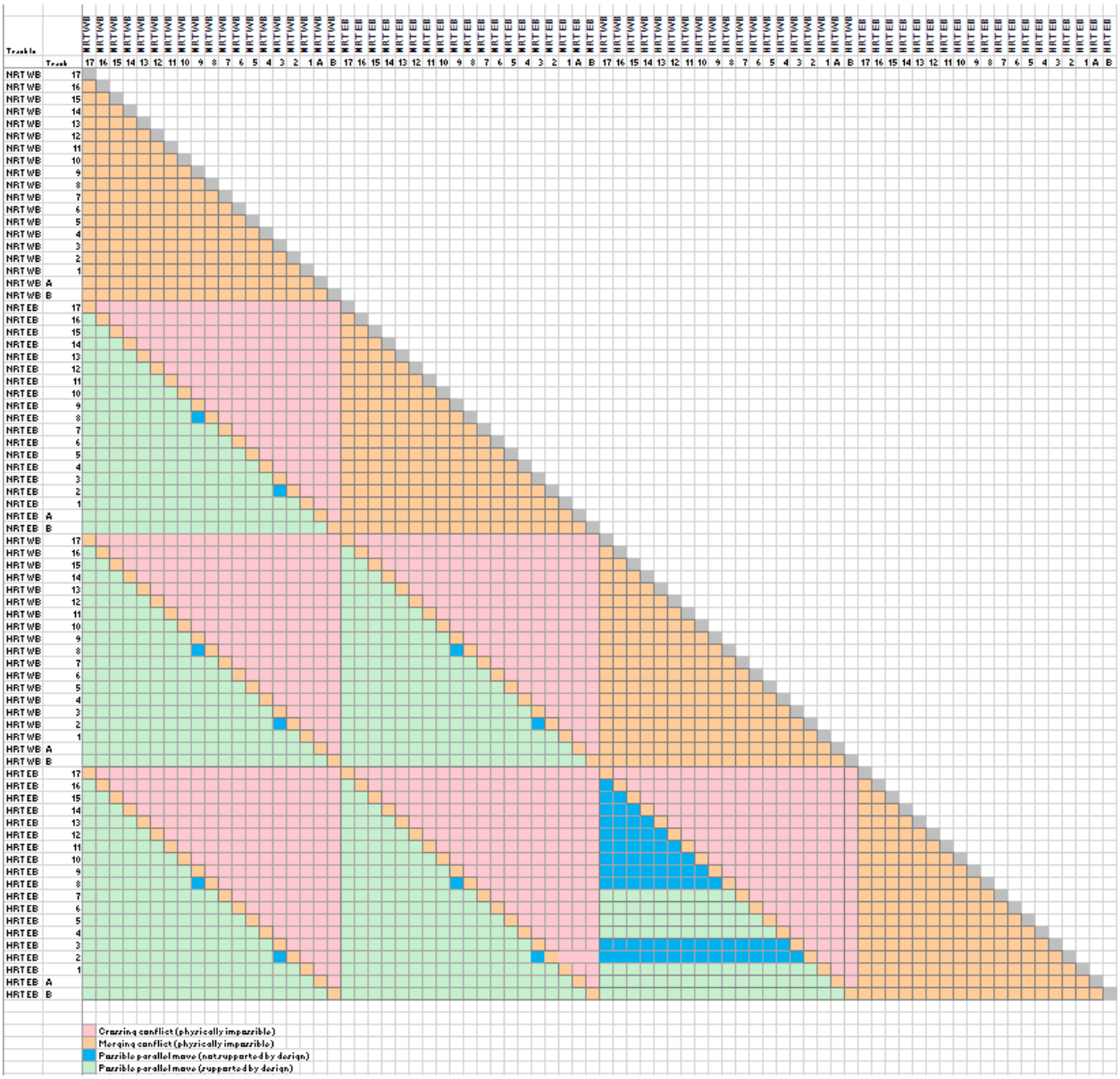
LTK & Arup evaluated the parallel move percentages of the two shortlisted near-to-medium term alternatives – Alt 12 + Alt 14 (Figure 32) versus Alt 13 + Alt 15 (Figure 33). Because of geometric complexities in accessing both the NRT and HRT, the supported percentages are somewhat lower than the 99% existing Penn Station percentage. Alt 13 + Alt 15 scores slightly better at 94% versus Alt 12 + Alt 14, which scores at 92%. Alt 12 + Alt 14 has other compelling advantages with its more westward orientation than Alt 13 + Alt 15 but this makes the geometrically-challenged ladder design more difficult.

The parallel move capability of "full build" (8 new platform edges) alternatives was also compared. When Alt 12 + Alt 14 (2 new platform edges) is expanded to 8 new platform edges to form Arup's Alt 12 + 14 + PSE revised concept design (Figure 34), the parallel move percentage drops from 92% to 86%. This is to be expected, as the number of routing permutations to the four Hudson River crossing tracks grows significantly. This design was compared to the Amtrak Gateway + PSE concept design (Figure 35), which scores slightly higher at 89%. The Gateway + PSE design constructs the 8 new station tracks farther east than the Arup design, providing greater flexibility in the design of the Penn Station throat. This explains the three-point parallel move benefit of the Gateway + PSE design versus the Alt 12 + 14 + PSE design. Nevertheless, the more westward orientation of the Alt 12 + 14 + PSE design provides important vertical circulation and constructability benefits that need to be included in the overall evaluation of the shortlisted alternatives.



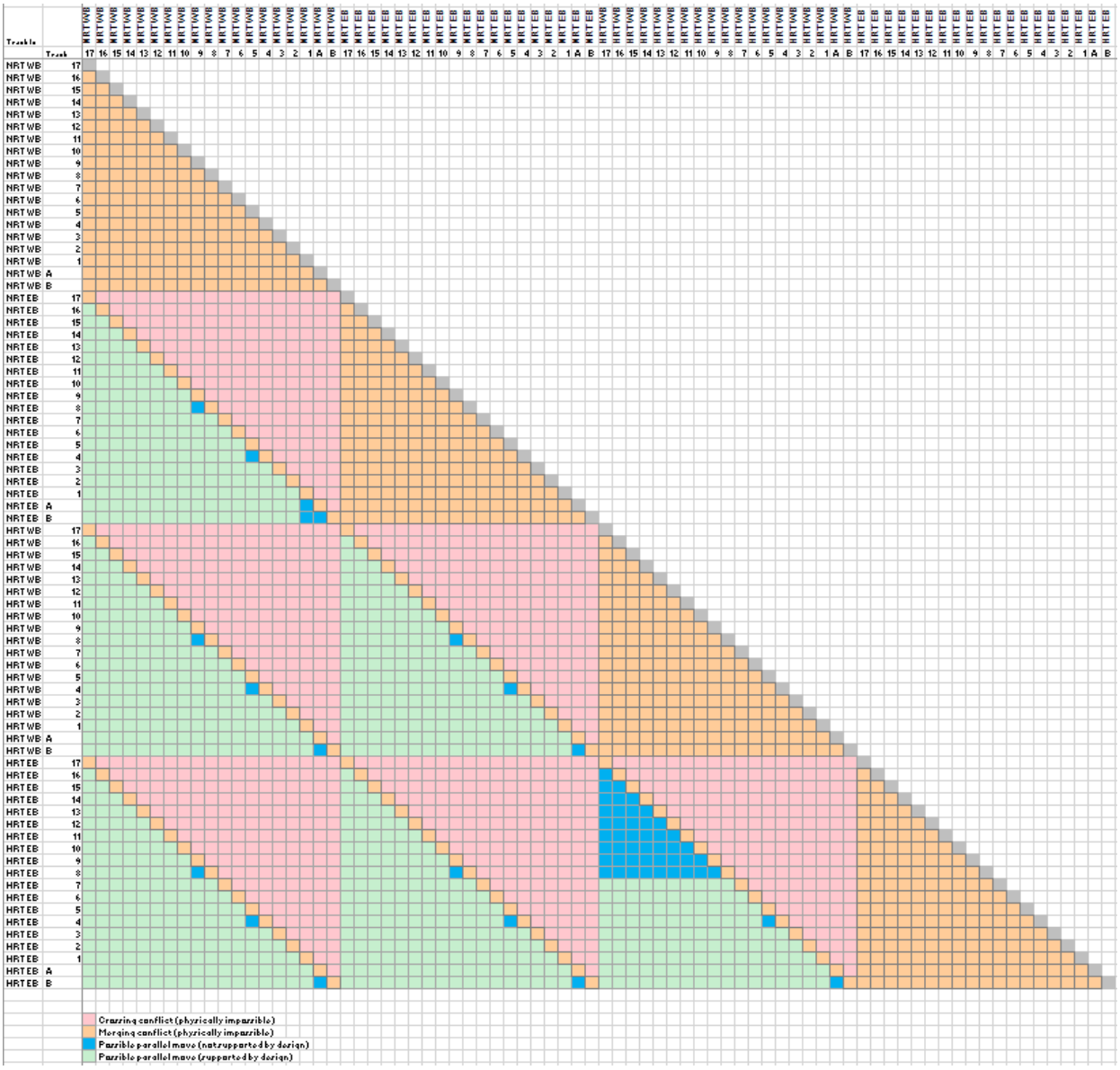
Source: Developed for the PCIP Study.

Figure 31: Parallel Move Analysis Results - Existing Track Configuration.



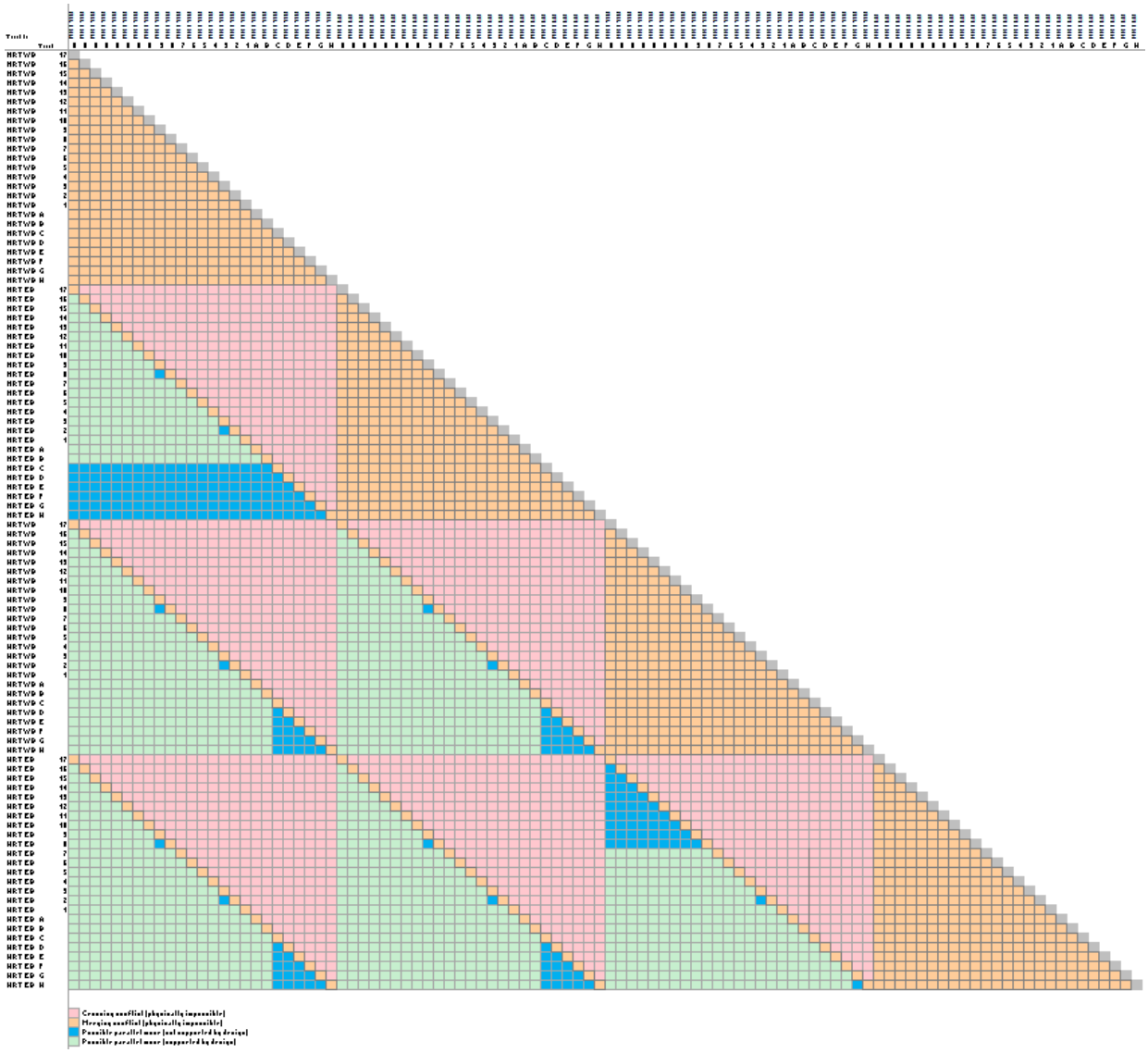
Source: Developed for the PCIP Study.

Figure 32: Parallel Move Analysis Results - Alt 12 + Alt 14 Track Configuration.



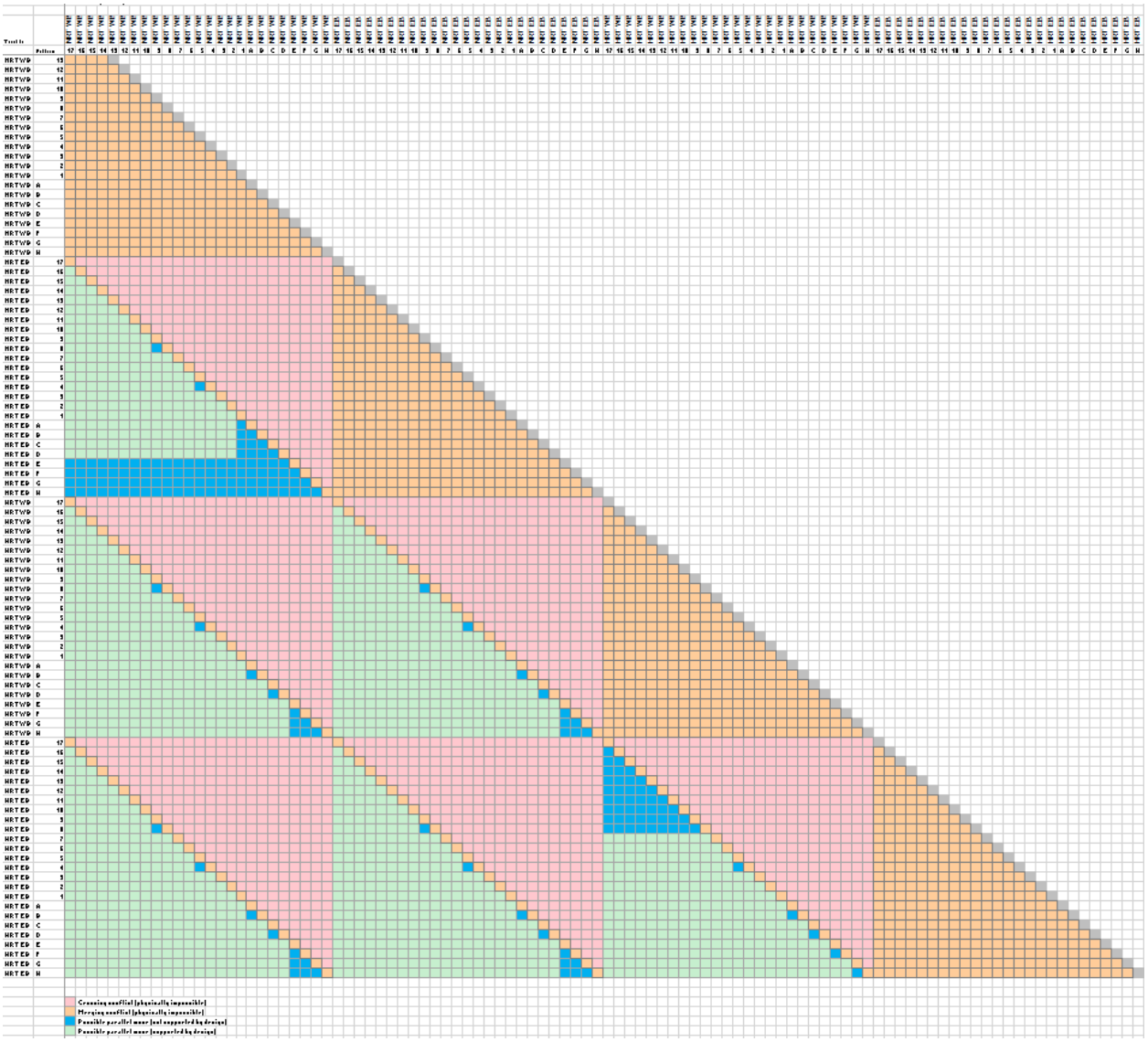
Source: Developed for the PCIP Study.

Figure 33: Parallel Move Analysis Results - Alt 13 + Alt 15 Track Configuration.



Source: Developed for the PCIP Study.

Figure 34: Parallel Move Analysis Results - Alt 12 + Alt 14 + Revised PSE Configuration.



Source: Developed for the PCIP Study.

Figure 35: Parallel Move Analysis Results - Amtrak Gateway + PSE Configuration.

8.1.2 Trans-Hudson and PSNY Terminal Capacity Analysis

Platform capacity benefits for the proposed infrastructure-oriented alternatives were compared with the trans-Hudson capacity achievable under operations alternatives with and without HRT. Estimated PSNY Terminal Capacity for longer-term alternatives was evaluated to consider how near-term alternatives influence the total number of new platforms required once the Hudson River Tunnels are in operation. In this analysis capacity refers to the maximum number of trains per hour (TPH) that would be supported by the NRT and HRT (trans-Hudson capacity) and by PSNY (terminal capacity). The alternatives that propose extending Platforms 1 and 2 (Alt 14 and 15) to support longer train consists would also provide additional seat capacity by increasing the number of cars per train consist, however this additional capacity is not reflected in the tables below.

This analysis assumed 2.5 TPH per Platform Edge at 22-minute revenue-to-revenue turn time and three TPH per Platform Edge at 18-minute revenue-to-revenue turn time. The results of this analysis are summarized in Figure 36, Figure 37 and Figure 38.

Preliminary Alternatives Analysis PSNY Overall Capacity Trans-Hudson and PSNY Terminal Capacity Analysis			**Infrastructure Improvements w/ 22 min Dwells**		
			PSNY Terminal Capacity (TPH)		
			Baseline	Alt 14 or 15	Alt 12 or 13
			Existing PSNY	Extend Platforms 1 and 2	New Island Platform
			26	26*	31
Trans-Hudson Capacity (TPH)	Existing NRT and PSNY Capacity	24	24	24	24
	NRT + X Tracks Improvements	26	26	26	26
	NRT + HRT	48	26	26	31

* Alt 14 and 15 would provide additional trans-Hudson and PSNY Terminal seat capacity. However, they would not increase TPH capacity.

Source: Developed for the PCIP Study.

Figure 36: Trans-Hudson and PSNY Terminal Capacity Analysis – 22-Minute Dwell.

Preliminary Alternatives Analsyis PSNY Overall Capacity Trans-Hudson and PSNY Terminal Capacity Analsyis			Infrastructure Improvements w/ 18 min Dwells		
			PSNY Terminal Capacity (TPH)		
			Baseline	Alt 14 or 15	Alt 12 or 13
			Existing PSNY	Extend Platforms 1 and 2	New Island Platform
			30	30*	36
Trans-Hudson Capacity (TPH)	Existing NRT and PSNY Capacity	24	24	24	24
	NRT + X Tracks Improvements	26	26	26	26
	NRT + HRT	48	30	30	36

* Alt 14 and 15 would provide additional trans-Hudson and PSNY Terminal seat capacity. However, they would not increase TPH capacity.

Source: Developed for the PCIP Study.

Figure 37: Trans-Hudson and PSNY Terminal Capacity Analysis – 18-Minute Dwell.

Preliminary Alternatives Analysis PSNY Overall Capacity Trans-Hudson and PSNY Terminal Capacity Analysis			Infrastructure Improvements w/ 18 min Dwells and No Temporal Separation		
			PSNY Terminal Capacity (TPH)		
			Baseline	Alt 14 or 15	Alt 12 or 13
			Existing PSNY	Extend Platforms 1 and 2	New Island Platform
			32	32*	38
Trans-Hudson Capacity (TPH)	Existing NRT and PSNY Capacity	24	24	24	24
	NRT + X Tracks Improvements	26	26	26	26
	NRT + HRT	48	32	32	38

* Alt 14 and 15 would provide additional trans-Hudson and PSNY Terminal seat capacity. However, they would not increase TPH capacity.

Source: Developed for the PCIP Study.

Figure 38: Trans-Hudson and PSNY Terminal Capacity Analysis – 18-Mininute Dwell W/O Temporal Separation.

The key findings of this analysis are:

- If the 22-minute revenue-to-revenue turn time is preserved (current condition):
  - A total of nine new platform edges would be required once HRT in service.
  - Advancing a new platform in near term would bring Penn Station capacity to 31 TPH once the HRT are in service.
  - The estimated increase over existing operations during the NRT rehabilitation (2&1 operations) is limited to five TPH.
  - An additional seven platform edges would be required to fully utilize NRT+HRT trans-Hudson capacity of 48 TPH.
  - Amtrak's plan for Penn Station Expansion (eight platform edges) would be inadequate to meet trans-Hudson capacity with the HRT.
- If the 18-min revenue-to-revenue turn time alternative is advanced (Alt OP1):
  - A total of 6 new platform edges would be required once the HRT are in service.
  - Advancing a new platform in the near term (Alt 12 or 13) would bring Penn Station capacity to 36 TPH once the HRT are in service.
  - There would be a potential 12 TPH increase over existing operations during the NRT rehabilitation (2&1 operations).
  - An additional four platform edges would be required to fully utilize NRT+HRT trans-Hudson capacity of 48 TPH.
  - Amtrak's plan for Penn Station Expansion could be reduced by two platform edges.
- Furthermore, if the 18-min revenue-to-revenue turn time alternative (Alt OP1) is advanced, then one additional maximum length track (such as Track 10) would be available for additional flexibility and enhanced reliability. Moreover, the number of new platforms required in the long term to meet NRT and HRT trans-Hudson capacity would be reduced.
- If the X-Tracks Improvements alternative is advanced (Alt OP2) and the 22-minute revenue-to-revenue turn time is maintained, the overall capacity (considering trans-Hudson and PSNY Terminal capacity) would increase by 2 TPH (to a total of 26 TPH). While no new platform edges would be required to meet the increased NRT trans-Hudson capacity, existing spare platform track availability would be eliminated.

8.1.3 Evaluation Summary and Results

The four infrastructure alternatives and the two operations-oriented alternatives were evaluated in detail following the approach developed as part of Task 3 of the PCIP and that is described in Chapter 4 of this report. The alternatives were evaluated across 23 separate criteria, which included 12 implementation-related criteria and 11 performance-related criteria, previously recommended to and agreed upon with NJ TRANSIT. Given the highly conceptual nature of this study, the alternatives evaluation method focused on major issues that could be

comparatively assessed using a combination of high-level quantitative and qualitative metrics and professional judgement on potential costs, benefits, risks, implementation challenges, and impacts.

Based on the results of the evaluation qualitative analysis, a red, yellow or green value was assigned to each alternative for each evaluation category to create a "stoplight chart". This tool is frequently used in the evaluation of alternatives as it supports both a visual and quantitative comparative analysis. Stoplight colors were assigned according to the following: Red = 1, Yellow =2 and Green =3 and lower values are associated with lower scores. As an example, the ideal and perfect alternative would obtain a score of "3" (Green) in all the evaluated metrics. In each Evaluation Group, a tally of the number of red, yellow, and green values was calculated to arrive at an overall total. This total value was then "normalized" by dividing the total tally by the number of evaluation criteria in each specific category, including the weighting factor, and rounded to the nearest tenth.

Weighting for the various evaluation criteria was determined through professional judgment, in close coordination with NJ TRANSIT, in consideration of the impact that each specific criterion would have on the relative deliverability and benefit of the alternatives. The weighting considered was limited to minimize any potential subjective influence on the results of the evaluation. With this goal in mind, the evaluation metrics were divided into "Important" and "Significantly Important" and they were assigned a weighting value of 1 (no weighting) and 2 respectively. Table 11 shows the metrics assigned into each group. After the evaluation analysis was completed, a limited sensitivity analysis was performed on the results to determine if the weighting considered had a significant impact on the outcome of the alternatives evaluation. This effort concluded that, while the absolute evaluation results would be slightly impacted based on the selected weighting, the relative results and conclusions obtained from comparing the alternatives would not change in the four scenarios considered: 1) recommended weighting, 2) no weighting, 3) weighting beneficial for alternative with lower score and 4) inverse from recommended weighting. Therefore, the weighting used was deemed acceptable as it did not have a meaningful impact on the relative results of the evaluation analysis.

Important Criteria (Not weighted – Value 1)	
Implementation	**Performance**
Design Criteria Compatibility	Reliability
Station Impacts	Service Plan - Frequency
Environmental Impacts	Pedestrian Connectivity
Regulatory Process Requirements	Operations & Maintenance
Stakeholder Requirements	Environmental Sustainability
Construction Schedule	Resiliency
	Compatibility with Planned Projects

Significantly Important Criteria (Weighted – Value 2)	
Implementation	**Performance**
Engineering Complexity	Operational Capacity
Operational Impacts	Passenger Capacity
Property Impacts	Cost Recovery
Constructability	
Risk	
Capital Construction Cost	

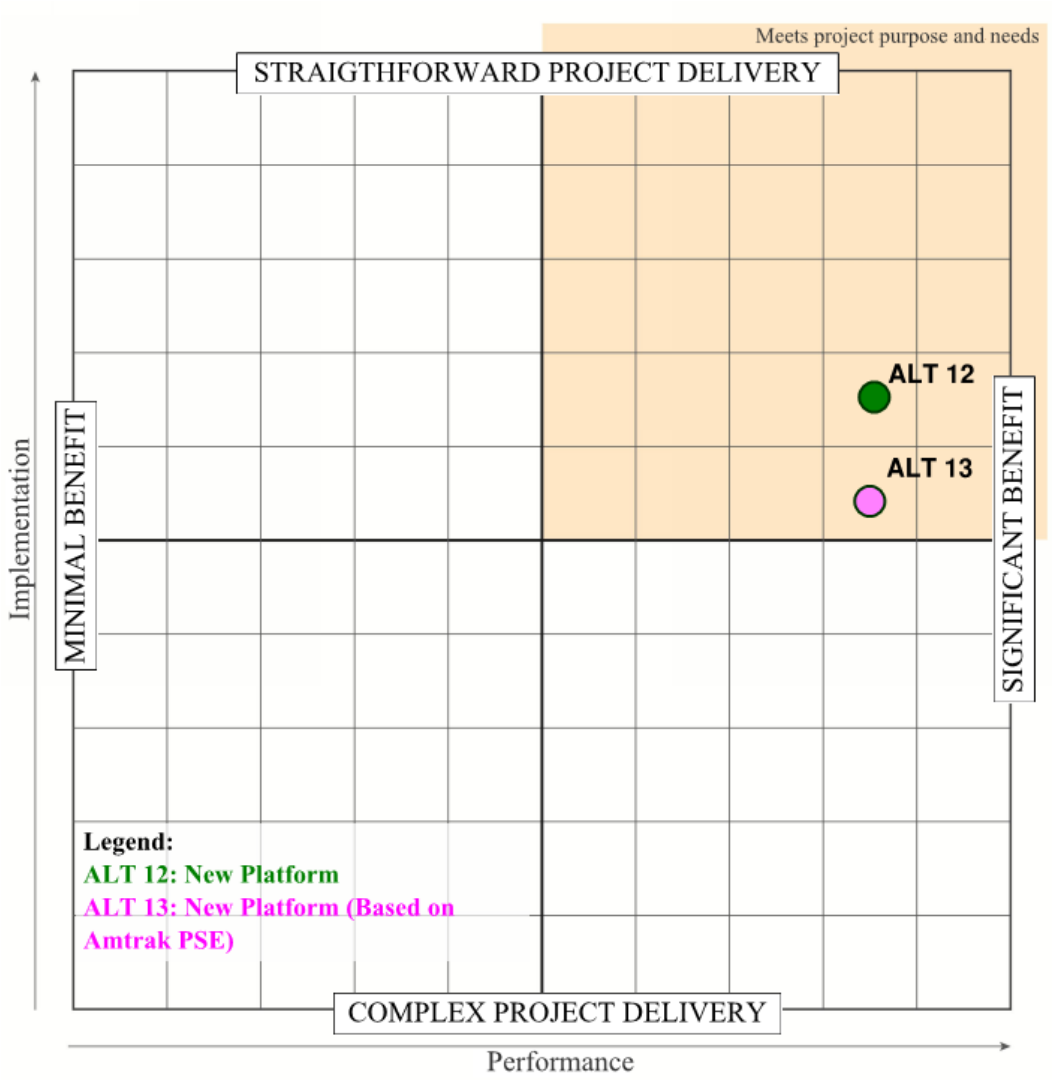
Source: Developed for the PCIP Study.

Table 11: Evaluation Criteria Weighting.

Infrastructure alternatives that proposed similar concepts were evaluated against each other in order to ensure a proper comparison. Based on this approach, Alt 12 was compared to Alt 13 since they both proposed building a new platform under 31st Street and Block 780 and Alt 14 was compared to Alt 15 since they both propose extending Platforms 1 and 2 to increase the length of trains that can be fully platformed. The two operations alternatives were evaluated against each other; however, these two alternatives are not mutually exclusive and both could be potentially advanced as they both would provide value and additional capacity in different ways. The evaluation results for these three groups of alternatives are summarized in Table 12, Table 13 and Table 14 respectively. In addition to the alternative scores, which are provided for each of the criterion analyzed, the tables provide a summary list of the specific items considered during the evaluation and comparison of alternatives and that justifies the score assigned. It is important to note that the evaluation analysis was performed for each group of alternatives independently and therefore scores assigned to a specific criterion on different evaluation tables are not comparable.

While the Stoplight Chart developed provides a great deal of information to support comparative analysis of competing alternatives, it can be hard to digest the amount of information provided. Hence, in addition to the Stoplight Chart developed to compare and evaluate the conceptually similar alternatives against each other, a Scatter Plot was also prepared to support a rapid comprehension and evaluation of the results obtained. This provides an additional tool to communicate the results obtained from the evaluation of alternatives as it delivers a visual ranking based on the alternatives' scores on the implementation and performance criteria.

The results of the evaluation of the alternatives that consider building a new platform (Alt 12 and 13), which are documented in Table 12, show that the implementation of both alternatives would be very challenging since the two options obtained low to very low scores in most of the implementation criteria due to the impacts on 31st Street, on the adjacent buildings and on PSNY operations and the difficulties that building a new platform would entail. The implementation score for Alt 12, which is the alternative being proposed by this project, was higher as it obtained better evaluation ratings in most of the metrics of the implementation criteria group. The impacts for this alternative are expected to be slightly lower because of the proposed location of the new platform. Nevertheless, the score for Alt 13, which is based on Amtrak PSE concept, was higher in Operational Impacts and in Station Impacts due mostly to the reduced track and station modifications that are required in this alternative. Both alternatives obtained the same score in Engineering Complexity and in Risk. Hence, from an implementation point of view Alt 12 would be preferred. Regarding the performance criteria, both alternatives obtained very similar scores. The minor differences are found in the Pedestrian Connectivity criterion, in which Alt 12 score was higher and the Compatibility with Planned Projects criterion, in which Alt 13 performed better. Figure 39 shows the scatter plot developed based on the evaluation results of these two alternatives. Overall, Alt 12 obtained a slightly higher score (2.0) than Alt 13 (1.8) and therefore, Alt 12 should be further studied and considered if building a new platform south of Platform 1 is an alternative that NJ TRANSIT is interested in advancing.

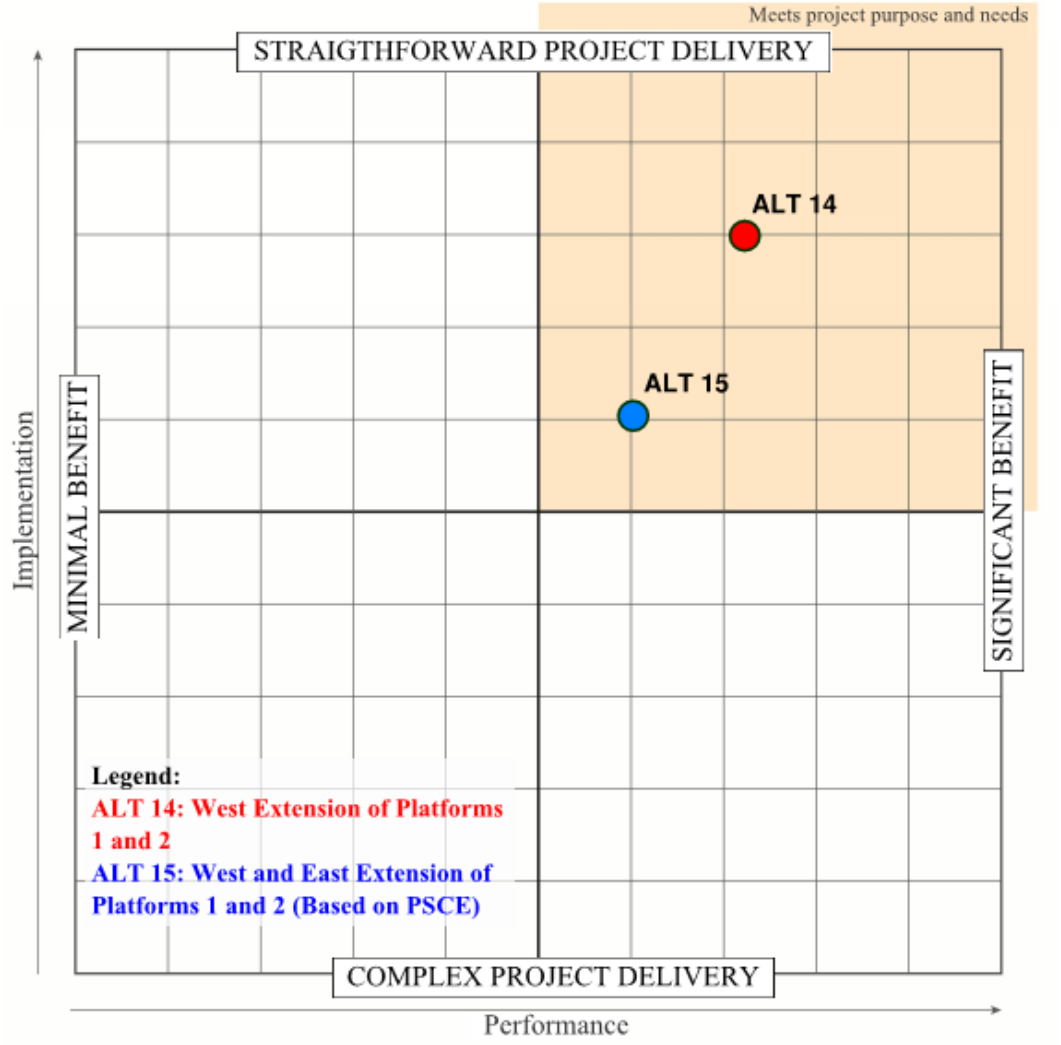


Source: Developed for the PCIP Study.

Figure 39: Alt 12 and 13 Evaluation Results - Scatter Plot.

Regarding Alt 14 and 15, the evaluation results, which are shown on Table 13, indicate that the westward extension of Platforms 1 and 2 (Alt 14) obtained a higher score on every criterion but on 1) Operational Impact, due mostly to the modifications this alternative proposes to "D" Yard and the "U" and "M" Ladders, and 2) Compatibility with Planned Projects as Alt 14 is not compatible with the current Amtrak design of PSE and compatibility of these two projects would require significant revisions on the Amtrak proposed track alignment. Nevertheless, Alt 14 would avoid impacting the 7th Avenue Subway and the 11 Penn Plaza Building and would provide extensions that support 12-car train consists and additional desired pedestrian connectivity. Figure 40 shows the scatter plot developed based on the evaluation results of these two alternatives. In summary, the conceptual evaluation performed suggests that the westward extension of Platforms 1 and 2 (Alt 14) (2.1 score), would be preferred over the PSCE western and eastern modifications of Tracks 1-4 (Alt 15) (1.4 score) based on both the

implementation and the performance criteria. Hence, extending Platforms 1 and 2 to the west is considered a better alternative and it is worth further exploring its implementation and continuing its design development.



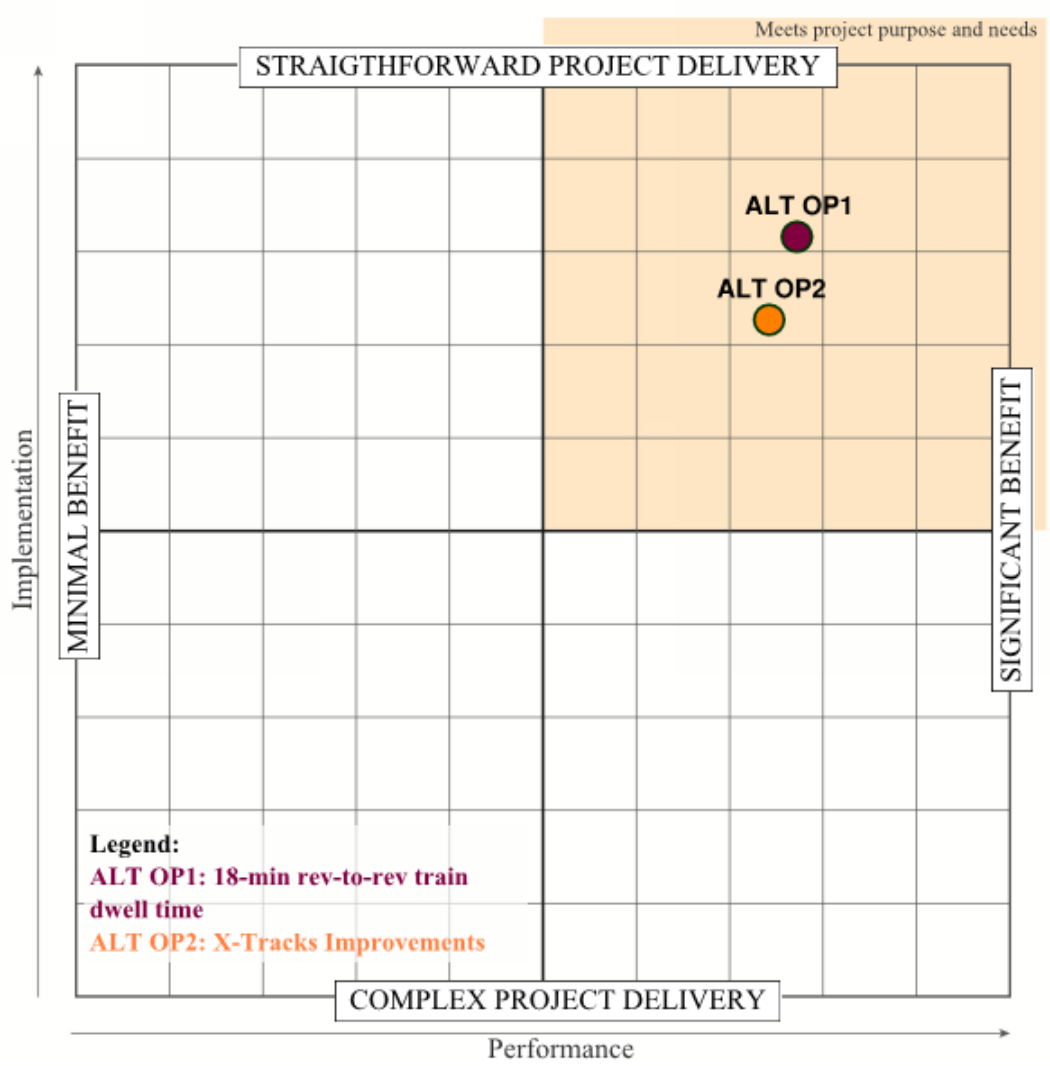
Source: Developed for the PCIP Study.

Figure 40: Alt 14 and 15 Evaluation Results - Scatter Plot.

The evaluation of the operations alternatives, which is documented in Table 14 showed that, unlike the infrastructure alternatives, these two options would have limited station, property, environmental and external stakeholder impacts. While these two alternatives proposed improvements that are conceptually very different, the evaluation analysis noted that the implementation of both alternatives would be complex due to the anticipated operational impacts, stakeholders' requirements and the extended implementation schedule.

Overall, Alt OP1, which proposes to reduce the minimum scheduled NJ TRANSIT revenue-to-revenue dwell time, obtained a slightly higher score on the implementation category as, unlike the X-Tracks Improvements (Alt OP2), major engineering and construction challenges are not

expected due to the nature of the modifications Alt OP1 proposes. Both options obtained similar scores on the performance evaluation, however reducing the current train dwell times (Alt OP1) will require significant changes to current O&M practices and funding and therefore the score of this alternative in this criterion was much lower than for Alt OP2. Finally, due to the modifications proposed in the operations alternatives, some of the criteria considered was not fully applicable and it is expected that opportunities to provide improvements within the scope of the alternative in areas like environmental sustainability, cost recovery, resiliency or pedestrian connectivity may be very limited, and the alternatives were scored accordingly. Figure 41 shows the scatter plot developed based on the evaluation results of these two alternatives. The overall score for Alt OP1 was higher (2.2) than for Alt OP2 (1.9); however, both alternatives propose improvements that are not mutually exclusive, and it is recommended that these options are further studied as they have the potential to improve capacity at PSNY in the near-term.



Source: Developed for the PCIP Study.

Figure 41: Operations Alternatives (Alt OP1 and OP2) Evaluation Results - Scatter Plot.

As concluded in the preliminary development and evaluation of alternatives, the six alternatives considered fall within the upper righthand quadrant of the scatter plot charts. This indicates that the conceptual alternatives considered meet the Penn Station Capacity Improvements Project purpose and needs as they have the potential to add capacity to PSNY in the next five to 10 years. Furthermore, by comparing and rigorously evaluating the infrastructure alternatives proposed in this project (Alt 12 and 14) against alternatives developed as part of separate projects (Alt 13 and 15), the evaluation analysis performed shows that not only the two alternatives envisioned and conceptually developed could be feasible but also that their consideration in future studies is warranted as they may provide a better option to improve capacity in the near-term at PSNY.

Of course, in addition to the limitations and assumptions previously described that have an impact on the outcome of this evaluation, any multicriteria evaluation analysis performed at this very preliminarily level of design (or at any design level for that matter) has an intrinsic limitation imposed by the fact that alternatives were evaluated under conditions of uncertainty regarding the real results and outcomes of their implementation.

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Alternatives Evaluation Summary Chart			PCIP Infrastructure Alternatives			
			Alt 12		Alt 13	
			New Platform under 31st Street and Block 780		Initial Phase of Amtrak Penn Station Expansion Project	
Implementation	Weighting	Weighted Tally	29		21	
		Normalized Tally	1.6		1.2	
	2	Engineering Complexity	1	• Underpinning of buildings south of 31st Street. • Extensive removal of the retaining wall. • Complex track and system works. • Underpinning of 8th Ave Subway. • 41 columns to be relocated.	1	• Assumed underpinning of buildings south of 31st Street. • Underpinning of St. John The Baptist Church and Affinia Hotel. • Partial removal of the retaining wall. • Complex track and system works. • Underpinning of 7th and 8th Ave Subways. • Reduced number of column relocations.
	1	Design Criteria Compatibility	2	• Deviation from Amtrak track and platform design standards.	1	• Deviation from Amtrak track and station platform standards. • Would exceed NJ TRANSIT platform gap requirements. • Future phases that include extension eastward under Sixth Avenue Subway present additional design criteria challenges.
	2	Operational Impacts	1	• Impacts on the "U" and "M" Ladders. • Impacts due to relocation of columns. • Significant reduction of "E" Yards storage capacity and removal of Tracks 1E, 2E and 3E. • Removal of Tracks 3D, 4D and 5D. • Demolition of significant portion of Diagonal Platform. • Extended closure of Track 1 for retaining wall removal.	2	• Reduced impacts on the "U" and "M" Ladders. • Reduced impacts due to column relocations. • Significant reduction of "E" Yards storage capacity and removal of Tracks 1E, 2E and 3E. • Reduced impact to Diagonal Platform.
	1	Station Impacts	1	• Closures due to extension of concourses and column relocations mostly impacting Platform 1. • Reframing of concourse areas for retaining wall removal.	2	• Closures due to extension of concourses and columns relocation mostly impacting Platform 1.
	2	Property Impacts	2	• Underpinning and partial demolition of buildings south of 31st Street. • Closure of 31st Street. • Significant impact on properties on Block 780. • Greater impact on properties on Block 754.	1	• Partial building demolition on the south side of 31st Street. • Underpinning of St. John The Baptist Church and Affinia Hotel. • Closure of 31st Street. • Significant impact on properties on Block 780. • Reduced impact on properties on Block 754 and Block 806.
	1	Environmental Impacts	2	• Archaeologically sensitive area. • Potential for contaminated soils and groundwater. • Reduced impact to existing land use.	1	• Underpinning of historic buildings (St. John the Baptist Church and Affinia Hotel). • Considerable impact to existing land use. • Archaeologically sensitive area. • Potential for contaminated soils and groundwater.
	1	Regulatory Process Requirements	2	• Review process for NEPA, SEQRA and CEQR. • Significant approvals at the federal, state and city level.	1	• Review process for NEPA, SEQRA and CEQR. • Significant approvals at the federal, state and city level. • More difficult regulatory process due to impacts on existing historic properties.
	1	Stakeholder Requirements	2	• Coordination and approval required by significant number of stakeholders. • Amtrak and NYCT reviews.	1	• Coordination and approval required by significant number of stakeholders. • Additional NYCT coordination due to underpinning of 7th Ave Subway. • Amtrak review. • Additional approvals for historic building impacts.
	2	Constructability	2	• Underpinning of buildings south of 31st Street. • Complete removal of the south retaining wall. • Complex track and system works. • Underpinning of 8th Ave Subway. • 41 columns to be relocated.	1	• Underpinning of historic buildings (St. John the Baptist Church and Affinia Hotel). • Partial removal of the south retaining wall. • Complex track and system works. • Underpinning of 7th and 8th Ave Subways. • Reduced number of columns relocated.
	2	Risk	1	• Considerable design, construction, budget and schedule risks (see risk table for details). • Force account support concerns.	1	• Considerable design, construction, budget and schedule risks (see risk table for details). • Force account support concerns.
	2	Capital Construction Cost	2	• Based on conceptual cost estimate.	1	• Based on conceptual cost estimate.
	1	Construction Schedule	2	• Based on conceptual schedule. • Extended process to secure approvals is expected.	1	• Based on conceptual schedule. • Extended process to secure approvals is expected.
Performance	Weighting	Weighted Tally	33		33	
		Normalized Tally	2.4		2.4	
		Customer Focused				
	1	Reliability	3	• Additional platform redundancy and train scheduling flexibility. • Significantly reduced storage capacity at "E" Yard.	3	• Additional platform redundancy and train scheduling flexibility. • Reduced storage capacity at "E" Yard.
	1	Service Plan - Frequency	3	• Potential to increase train frequency once HRT is completed. • Provide two additional platform edges.	3	• Potential to increase train frequency once HRT is completed. • Provide two additional platform edges.
	1	Pedestrian Connectivity	3	• New concourse level and additional pedestrian connections to existing concourses in PSNY. • Provides connection to the West End Concourse. • New Concourse A providing greater east-west connectivity. • Significant additional vertical circulation (stairs, escalators and elevators) provided.	2	• New concourse level and additional pedestrian connections to existing concourses in PSNY. • Provides access east of 7th Ave. • No connection provided to West End Concourse. • Additional vertical circulation (stairs, escalators and elevators) provided.
		Operational Focused				
	2	Operational Capacity	2	• Completion of HRT is necessary to fully utilized additional platform capacity provided. • Parallel moves supported on new tracks to connect to both NRT and HRT.	2	• Completion of HRT is necessary to fully utilized additional platform capacity provided. • Parallel moves not supported on new tracks.
	1	Operations & Maintenance	1	• Higher O&M cost to support service on new platform and concourses. • Slightly higher O&M cost to support new tracks and systems. • Significantly reduced storage capacity at "E" Yard. • Removal of Tracks 3D , 4D and 5D. • Benefits from additional train and egress capacity could add reliability and operational flexibility and reduce incident management challenges.	1	• Higher O&M cost to support service on new platform and concourses. • Slightly higher O&M cost to support new tracks and systems. • Reduced storage capacity at "E" Yard. • Benefits from additional train and egress capacity could add reliability and operational flexibility and reduce incident management challenges.
	2	Passenger Capacity	3	• New 1020 ft-long island platform.	3	• New 1020 ft-long island platform.
		Program Focused				
	1	Environmental Sustainability	2	• New concourse, platforms and potential development present good opportunities for sustainable improvements.	2	• New concourse, platforms and potential development present good opportunities for sustainable improvements.
	2	Cost Recovery	2	• Additional capacity for added fare revenue. • Development opportunities on lots where buildings are demolished. • Air rights opportunities.	2	• Additional capacity for added fare revenue. • Development opportunities on lots where buildings are demolished. • Air rights opportunities.
	1	Resiliency	3	• Opportunity to improve resiliency of existing systems. • Additional platform capacity and egress capacity for incident management.	3	• Opportunity to improve resiliency of existing systems. • Additional platform capacity and egress capacity for incident management.
	1	Compatibility with Planned Projects	2	• Compatible with a revised design of the PSE Project. • Compatible with future planned projects, including HRT and PSNY Central Concourse Extension. • Can be combined with Alt 14 to provide significant synergies.	3	• Compatible with PSE Project. • Compatible with future planned projects, including HRT and PSNY Central Concourse Extension. • Design could be revised to be compatible with west extension of Platforms 1 and 2. • Design could potentially support tail tracks extending east below the 6th Ave Subway and potentially to Queens.
	1	Project Based Value	2	• Can be advanced independently to improve operations reliability and resiliency. • Improved passenger circulation within PSNY and to street surface. • Once HRT is completed, would provide capacity and support 2+1 operations while performing maintenance on NRT.	2	• Can be advanced independently to improve operations reliability and resiliency. • Improved passenger circulation within PSNY and to street surface. • Once HRT is completed, would provide capacity and support 2+1 operations while performing maintenance on NRT.

Weighting	Group	Results Summary			
1	Implementation Considerations	1.6		1.2	
1	Performance Considerations	2.4		2.4	
FINAL Alternative Score		2.0		1.8	

Source: Developed for the PCIP Study.

Table 12: Alt 12 and 13 Evaluation Summary

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Alternatives Evaluation Summary Chart			PCIP Infrastructure Alternatives			
			Alt 14		Alt 15	
			West Extension of Platforms 1 and 2		PSCE - Eastern and Western Extension of Tracks 1-4	
Implementation	Weighting	Weighted Tally	40		25	
		Normalized Tally	2.2		1.4	
	2	Engineering Complexity	2	• Relocation of 13 columns supporting the 8th Ave Subway. • Relocation of 62 columns supporting concourse above. • Complex track and system works.	1	• Relocation of 6 columns supporting the 8th Ave Subway. • Excavation under and underpinning of 7th Ave Subway. • Complex track and system works. • Removal of east retaining wall section. • Complex relocation of communications, signals, and substation facilities at east end of existing tracks 1-4. • Complex connection to 11 Pennsylvania Plaza Building , 7th Ave Subway Station and West End Concourse.
	1	Design Criteria Compatibility	2	• Deviation from Amtrak track and station platform standards.	1	• Deviation from Amtrak track and station platform standards. • Use of custom No. 7 and N. 6 turnouts on M Ladder. • Would exceed platform gap requirements. • Constrained connection to West End Concourse.
	2	Operational Impacts	1	• Considerable impacts on the "U" and "M" Ladders. • Significant impacts due to column relocations. • Minor reduction of "E" Yards storage capacity. • Removal of Tracks 3D , 4D and 5D. • Demolition of significant portion of Diagonal Platform. • Extended closures of Tracks 1, 2 and 3 for westward extension of platforms.	2	• Reduced impacts on the "U" and "M" Ladders. • Reduced impacts due to column relocations. • Eastward extension of platforms minimizes impact to operations. • Relocation of systems equipment on east end of platforms would have to be careful sequenced to limit impacts.
	1	Station Impacts	2	• Impacts due to extension of the West End Concourse and column relocations. • Impacts to Platforms 1 and 2 limited to west end.	2	• Impacts due to connection to the West End Concourse. • Reduced columns relocation. • Greater impacts to platform areas currently in use.
	2	Property Impacts	3	• Reduced property impacts anticipated. • Impacts expected would be in PSNY.	1	• Impact to 11 Pennsylvania Plaza Building basement. • Partial closure of 7th AVE and partial closure of 31st Street.
	1	Environmental Impacts	3	• No expected impact to existing land use. • Potential for contaminated soils and groundwater.	2	• No expected impact to existing land use. • Potential for contaminated soils and groundwater.
	1	Regulatory Process Requirements	2	• Review process for NEPA, SEQRA and CEQR. • Approvals at the federal, state and city level required.	1	• Review process for NEPA, SEQRA and CEQR. • Approvals at the federal, state and city level required. • More difficult regulatory process due to 11 Pennsylvania Plaza Building and street impacts.
	1	Stakeholder Requirements	2	• Coordination and approval required by reduced number of stakeholders.	1	• Coordination and approval required by higher number of stakeholders. • Additional NYCT coordination due to underpinning of 7th Ave Subway. • Additional approvals due to 11 Pennsylvania Plaza Building and street impacts.
	2	Constructability	2	• Relocation of 13 columns supporting the 8th Ave Subway. • Relocation of 62 columns supporting concourse above. • Reconfiguration of the "U" and "M" Ladders and design of "T" and "R" Ladders. • Complex track and system works.	1	• Relocation of 6 columns supporting the 8th Ave Subway. • Excavation under and underpinning of 7th Ave Subway. • Column impacts to 11 Pennsylvania Plaza Building. • Removal of east retaining wall section. • Complex track and system works.
	2	Risk	2	• Design, construction, budget and schedule risks.	1	• Design, construction, budget and schedule risks. • Requires additional approvals with 11 Penn Plaza and with NYCT.
	2	Capital Construction Cost	3	• Based on conceptual cost estimate.	2	• Based on conceptual cost estimate.
	1	Construction Schedule	3	• Based on conceptual schedule.	2	• Based on conceptual schedule.
Performance	Weighting	Weighted Tally	27		20	
		Normalized Tally	1.9		1.4	
		Customer Focused				
	1	Reliability	2	• Greater flexibility for platforms assignments • Reduction of operational conflicts • Minor reduction in storage capacity at "E" Yard	1	• Greater flexibility for platforms assignments. • Reduction of operational conflicts.
	1	Service Plan - Frequency	2	• Additional seat capacity trans-Hudson • Supports 12-car train consists	1	• Additional seat capacity trans-Hudson. • Supports 11-car train consists.
	1	Pedestrian Connectivity	3	• Connection to the West End Concourse and additional egress stairs to Exit Concourse • Additional vertical circulation (stairs, escalators and elevators) provided.	2	• Constrained connections to the West End Concourse via narrow track level enclosed walkway and narrow stairs. No elevator. • Connection to 34th Street Station of Seventh Avenue subway, but constrained and no elevator.
		Operational Focused				
	2	Operational Capacity	2	• Additional seat capacity trans-Hudson • Supports 12-car train consists • Greater flexibility for platforms assignments • Reduction of operational conflicts • Improves operations on "U" and "M" Ladders	1	• Additional seat capacity trans-Hudson. • Supports 11-car train consists. • Greater flexibility for platforms assignments. • Reduction of operational conflicts.
	1	Operations & Maintenance	2	• Reduced storage capacity at "E" Yard. • Benefits from additional train and egress capacity could add reliability and operational flexibility and reduce incident management challenges. • Slightly higher O&M costs for extended platforms and concourse extensions, but offset by operational benefits.	2	• Benefits from additional train and egress capacity could add reliability and operational flexibility and reduce incident management challenges. • Slightly higher O&M costs for extended platforms and concourse extensions, but offset by operational benefits. • Additional challenges with maintenance of long passageway through 11 Penn Plaza. • Additional maintenance due to custom turnouts
	2	Passenger Capacity	2	• Platforms 1 and 2 extended to 1020 ft to support 12-car train consists. • Additional seat capacity trans-Hudson.	1	• Platforms 1 and 2 extended to support 11-car train consists. • Additional seat capacity trans-Hudson.
		Program Focused				
	1	Environmental Sustainability	1	• Limited sustainable design opportunities.	1	• Limited sustainable design opportunities.
	2	Cost Recovery	1	• Increase fare revenue through added seat capacity.	1	• Increase fare revenue through added seat capacity.
	1	Resiliency	2	• Better flexibility for incident response. • Additional platform capacity. • Additional access and pedestrian connections to the West End Concourse and the Exit Concourse.	1	• Lower additional platform capacity and incident response provided. • Additional access and pedestrian connections to the West End Concourse and the 7th Ave Subway.
	1	Compatibility with Planned Projects	2	• Compatible with a revised design of the PSE Project. • Compatible with future planned projects, including HRT and PSNY Central Concourse Extension. • Can be combined with Alt 12 to provide significant synergies.	3	• Compatible with the PSE Project. • Compatible with future planned projects, including HRT and PSNY Central Concourse Extension. • Although not practical, design could be revised to be compatible with ATL 12.
	1	Project Based Value	3	• Can be advanced independently with no impact to benefits provided.	3	• Can be advanced independently with no impact to benefits provided.
	Weighting	Group				
	1	Implementation Considerations	2.2		1.4	
	1	Performance Considerations	1.9		1.4	
	FINAL Alternative Score		2.1		1.4	

Source: Developed for the PCIP Study.

Table 13: Alt 14 and 15 Evaluation Summary

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Alternatives Evaluation Summary Chart			PCIP Operations Alternatives			
			Alt OP1		Alt OP2	
			18-min Revenue-to-Revenue Dwell Time		X-Tracks Improvements	
Implementation	Weighting	Weighted Tally	42		34	
		Normalized Tally	2.3		1.9	
	2	Engineering Complexity	3	NA.	2	• Requires track and signal changes at critical entry to PSNY from NRT. • May require tunnel portal modifications.
	1	Design Criteria Compatibility	3	NA.	1	• Potentially requires use of No. 12 turnouts which are non-standard.
	2	Operational Impacts	1	• Requires major change in operations procedures. • It is expected that service would not be significantly impacted during the implementation of these operational changes.	1	• Considerable impact due to critical area for construction work. Impact on NRT South Track No. 2 and on Tracks 1X, 2X and 3X.
	1	Station Impacts	2	• Reduced station impacts anticipated (additional facilities to support increased crew roster, etc.)	3	• Minimal or no station impacts anticipated.
	2	Property Impacts	3	• Minimal or no property impacts anticipated.	3	• Minimal or no property impacts anticipated.
	1	Environmental Impacts	3	• Increased capacity has beneficial environmental impacts.	3	• Increased capacity has beneficial environmental impacts. • Possible contaminated soils from trackwork.
	1	Regulatory Process Requirements	2	NA.	2	NA.
	1	Stakeholder Requirements	1	• Requires major change in operations procedures.	2	• Amtrak approval of non-standard turnouts.
	2	Constructability	3	• NA - major construction is not anticipated.	1	• Critical area for construction. • May require tunnel portal modifications.
	2	Risk	2	• Risk of approvals from NJ TRANSIT departments.	2	• Critical area for construction. • Risk of approvals from Amtrak.
	2	Capital Construction Cost	3	• Cost of any improvements to facilities and existing infrastructure to support the operational changes proposed.	2	• Improvements proposed would result in high costs due to the critical area for construction.
	1	Construction Schedule	1	• Extended process to secure approvals is expected.	1	• Extended process to secure approvals is expected.
Performance	Weighting	Weighted Tally	30		28	
		Normalized Tally	2.1		2.0	
		Customer Focused				
	1	Reliability	2	• Reduced turn times would require increased operational discipline.	2	• Non-standard turnouts could create reliability problems, but with proper maintenance the higher number turnout should improve reliability.
	1	Service Plan - Frequency	3	• In the near-term, it could increase frequency only if "X" Tracks improvements advanced. • In the long-term, it could increase frequency once HRT are in place.	2	• Could increase frequency.
	1	Pedestrian Connectivity	1	• NA - Pedestrian connectivity improvements are not provided.	1	• NA - Pedestrian connectivity improvements are not provided.
		Operational Focused				
	2	Operational Capacity	3	• In the near-term, it could increase frequency only if "X" Tracks improvements advanced. • In the long-term, it could increase frequency once HRT are in place.	2	• Beneficial operations change to movements between 1X and 3X. Potential speed increase to 30MPH. • Could increase train frequency and increase the maximum train volume during peak time by 2 TPH.
	1	Operations & Maintenance	1	• Significant changes required to O&M practices and funding. • Increased costs associated with increased capacity.	3	• Non-standard turnouts could require additional O&M costs. • Overall, minor impact is anticipated on O&M costs.
	2	Passenger Capacity	3	• In the near-term, it could increase frequency only if "X" Tracks improvements advanced. • In the long-term, it could increase frequency once HRT are in place.	3	• Could increase train frequency and increase the maximum train volume during peak time by 2 TPH.
		Program Focused				
	1	Environmental Sustainability	1	• Limited sustainable design opportunities.	1	• Limited sustainable design opportunities.
	2	Cost Recovery	1	• Limited cost recovery opportunities.	1	• Limited cost recovery opportunities.
	1	Resiliency	2	• Potential to improve resiliency due to additional platform capacity provided. • Requires increased operational discipline.	1	• Limited resiliency improvement opportunities.
	1	Compatibility with Planned Projects	3	• Compatible with future planned projects.	3	• Compatible with future planned projects.
	1	Project Based Value	3	• Can be advanced independently with no impact to benefits provided. In the near term it would provide reliability improvements. Once HRT are completed, it would reduce additional platforms required.	3	• Can be advanced independently with no impact to benefits provided.
	Weighting	Group	Group			
	1	Implementation Considerations	2.3		1.9	
	1	Performance Considerations	2.1		2.0	
		FINAL Alternative Score	2.2		1.9	

**Operations alternatives were evaluated independently since they are conceptually different improvements. These two alternatives are not mutually exclusive and they both could be advanced.*

Source: Developed for the PCIP Study.

Table 14: Alt OP1 and OP2 Evaluation Summary.

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8.2 Alternatives Selection and Next Steps

The comparison and evaluation of the conceptual alternatives proposed in this high-level exploratory effort has determined that there are several infrastructure and operations alternatives to improve capacity at PSNY in the near term.

Given the conceptual level of this effort, significant additional study, investigation, development and coordination would be required to move these alternatives forward. Next stages of design should further consider important items such as rail operations, traction power/catenary, communications and signaling, structural impacts, ventilation, fire-life safety, property acquisition, permitting, environmental sensitivities, construction phasing and funding opportunities. Potential recommended next steps to strategically advance some of the alternatives conceptually developed in this project are outlined below. The aim of these next steps proposed is to provide suggestions on actions that can be taken to advance planning for the alternatives selected through this study to increase PSNY capacity in the near term.

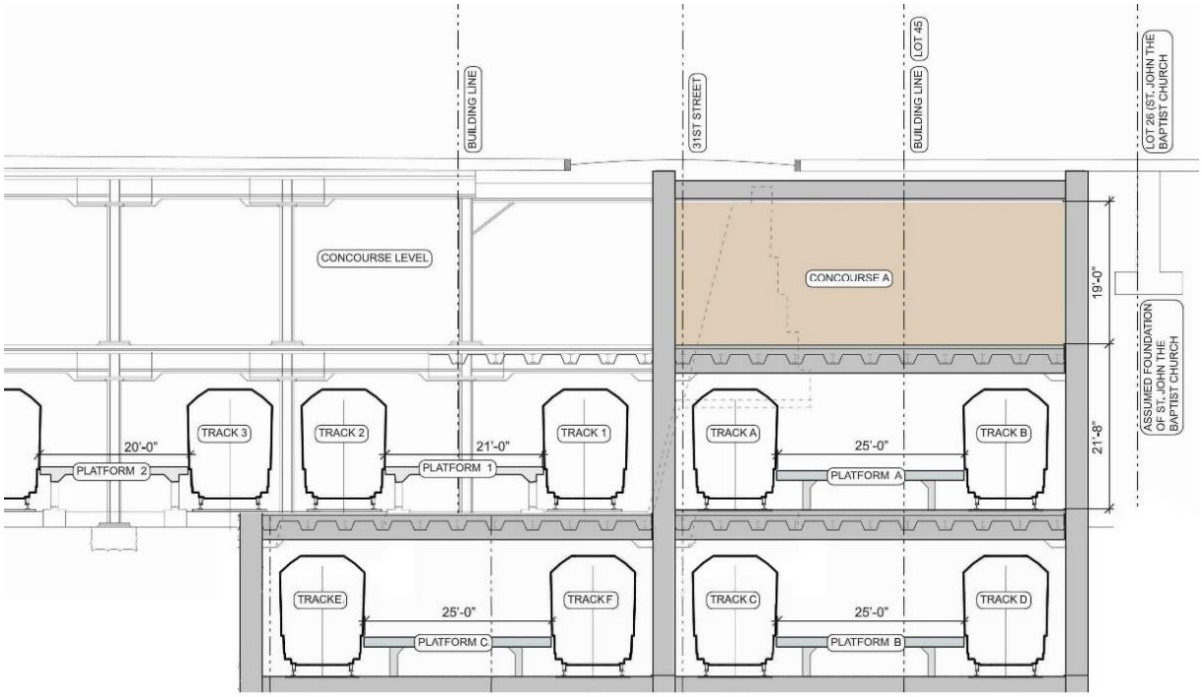
This final report recommends the following next steps that should be taken to advance these alternatives as part of a future study effort:

- Perform focused modeling and micro operation simulations of the selected alternatives proposed in this Study to gain a better understanding of the potential performance of the alternatives and to more accurately estimate potential capacity benefits.
- Continue coordination with Amtrak, its consultants, and other relevant stakeholders to gather input as appropriate on the alternatives developed within the PCIP Study and, more importantly, to ensure that NJ TRANSIT interests are properly considered in their project planning.
- Develop 10% conceptual engineering design for the preferred infrastructure alternatives identified in the PCIP Study, Alts 12 and 14. The next stage of design for this alternative would involve further development of structural, track, architectural, fire and life safety systems, and other systems elements, as well as further constructability, cost, and schedule reviews. Close coordination with Amtrak would be required to incorporate their considerations as appropriate and to resolve any concerns they may have regarding potential compatibility issues with future planned projects. If only one of these two alternatives were selected to advance and precluding the other is acceptable, the proposed track layout of the selected alternative could be further studied and optimized. Moreover, this effort could study the feasibility and evaluate the benefits of advancing a modified version of Alt 14 that in addition to extending Platforms 1 and 2 also widens Platform 1 to improve passenger circulation and comfort.
- Assess and evaluate the benefits of implementing both infrastructure alternatives proposed (Alt 12 and Alt 14) in combination to maximize potential near-term capacity increases at PSNY. The conceptual track layout developed for the new platform A proposed (Alt 12) is compatible with the westward extension of Platforms 1 and 2 (Alt 14) and the two

alternatives have major common elements. As such, implementing these two alternatives in combination would reduce cost and implementation schedules – the two project costs and schedules would not be additive if both were advanced. Additional effort is proposed to understand and further develop and evaluate these two alternatives as a phased plan.

- Further evaluate the issues involved with reducing the NJ TRANSIT minimum revenue-to-revenue turn time as proposed in Alt OP1 to 18 minutes from the present 22 minutes. This would include analysis of tradeoffs between capacity and reliability benefits gained and additional O&M costs incurred. This could potentially include analysis of a more modest reduction to 20-minute revenue-to revenue turn times that would offer platform capacity benefits that might better match HRT capacity gains possible with the "X" Tracks improvements and reduce challenges of implementing the operational change. Alt OP1 also provides synergistic benefits with Alts 12 and 14.
- Develop 10% conceptual engineering design for the "X" Tracks improvements (Alt OP2) after confirming that the eastward extension of ACSES II PTC to the "X" Tracks themselves is feasible. The next stage of design for this alternative would require significant track, structural, and systems design efforts, and close coordination with Amtrak to gather any concerns and requirements. Amtrak review and acceptance of the design would be required for the project to advance given potential impact on the existing tunnel portal and potential signal design complexities. Considering the critical location of the improvements proposed, a detailed implementation staging plan should also be developed early on to ensure that impacts to operations are minimized.
- Study of the feasibility and optimal configuration of the reintroduction of a bellmouth into the HRT project design to provide for additional opportunities to add significant capacity near PSNY in the future. The bellmouth would be redesigned to avoid the level crossings included in the original HRT design to optimize operational performance. Study would require close coordination with Amtrak and NJ TRANSIT.
- Further develop the longer-term alternatives identified in the PCIP Study that were outside the goals and objectives of this Study including:
    - A potential new two-platform-level, four-track stack station under 31st Street with a connection to a bellmouth on the proposed HRT approach to PSNY. This option would leverage the excavation required to build the new Platform A proposed under Alt 12 to develop a second platform level underneath this platform. The lower level of this new complex could be extended to include an additional island platform under Platform 1 as shown on Figure 42. The four new tracks on the lower level would allow for extension to Queens.
    - A potential deep-level station near PSNY with a connection to a redesigned bellmouth on the proposed HRT approach to PSNY.
- Study of potential alternative project delivery approaches and funding mechanisms to advance the projects identified in the PCIP study.

- Study impacts of PTC on overall train operation at PSNY and its approaches.



Source: Developed for the PCIP Study.

Figure 42: Potential concept for building three new platforms on the south side of PSNY.

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9 Conclusions and Recommendations

The PCIP exploratory planning effort identified feasible alternatives that could be pursued to provide PSNY capacity relief in the near-term while planning, funding, and construction is in progress for the larger Gateway initiatives and possible significant capacity expansion of PSNY. This DRAFT Final Report documents the work completed in close coordination and collaboration with NJ TRANSIT and presents the results of the PCIP Study.

The PCIP Study included development of the PCIP Document Catalog, which was developed through the identification, collection, and review of the primary existing and planned constraints to and proposals for capacity expansion at Penn Station. The effort gathered together the information determined to be most relevant to study of possible PSNY capacity expansion into a basic database of information developed specifically under this study for NJ TRANSIT. The project developed a base map of the study area based on the compiled survey files and engineering and as-built drawings received from different completed and on-going projects and created a conceptual 3D model of PSNY to better visualize and communicate the main existing spatial constraints. It is expected that this consolidation of existing constraints and proposed improvements in the PSNY area will prove useful in future studies and evaluation of proposals for capacity improvements. In addition, the project created an approach to the development and evaluation of conceptual alternatives to establish an objective and defensible method for the screening of competing alternatives and the evaluation of project impacts and benefits.

Using the information gathered, and through coordination with NJ TRANSIT, the project identified and developed to a highly conceptual level fourteen infrastructure and three operations alternatives (described in Section 1 of this report) with the potential to increase PSNY capacity and improve operational flexibility and reliability. A screening effort focused on the spatial feasibility of alternatives, their consistency with design criteria, and their compatibility with project goals and objectives was used to complete a preliminary evaluation of the conceptual alternatives, which lead to the following conclusions:

- Several of the preliminary alternatives considered (Alt 1, 2, 3, 4, 5, 7 and 8) are not spatially feasible, are not compatible with design criteria, or do not satisfy the project goals and objectives.
- The study answered some key questions long raised regarding the feasibility of PSNY improvements.
    - The preliminary study revealed that the extension of tracks 1-4 from the existing Penn Station level below the 6th Avenue Subway is infeasible (Alt 5) based on reasonable grade-related design standards.
    - Building a new platform south of Track 1 and beneath 31st Street without impacting the buildings on Block 780 is not feasible based on existing spatial constraints. The concept envisioned at the outset of the project, namely provision of new tracks and a platform below 31st Street at the same elevation of existing platforms and tracks and

extension past 6th Avenue, is infeasible given the constrained space within 31st Street and the elevation of the NYCT 6th Avenue Subway.

- The study of the three conceptual alternatives (Alt 6, 9 and 10) that would provide considerable additional capacity by building new tracks and tunnels revealed that they are conceptually feasible from a spatial and track geometry perspective. However, these alternatives represent longer-term options requiring significant capital investment and therefore they only partially satisfied the goals and objectives of this project. Hence, it is recommended that these alternatives are further studied and developed as part of a future study to add capacity to PSNY as an incremental addition after HRT is in place or as part of the Gateway Expansion Program. Those additional studies would need to focus on constructability concerns and pedestrian connectivity between new station areas and existing PSNY, the local subway network, and the street surface.
- The preliminary review identified many infrastructure alternatives (Alt 11, 12, 13, 14 and 15) and operational alternatives (Alt OP1, OP2 and OP3) that are feasible, that are compatible with design criteria, and that satisfy the project goals and objectives.

Based on the existing spatial constraints, the input obtained from NJ TRANSIT, and professional judgement considering potential benefits, cost, impacts, alternatives compatibility, and risks, the PCIP Study selected, further developed, and evaluated six alternatives.

Selected Infrastructure Alternatives

The four infrastructure alternatives selected were grouped and compared based on the conceptual improvements that they proposed.

- Two infrastructure alternatives to build a new platform south of Track 1 that are compatible with plans for the new HRTs:
  - Build new platform and two tracks under 31st Street and the northernmost part of Block 780 (Alt 12).
  - Build the northernmost platform and two tracks of the Amtrak Penn Station Expansion (PSE) concept (Alt 13). This would be considered the initial phase of PSE.
- Two infrastructure alternatives to extend Tracks 1-4 and Platforms 1 and 2 to support longer trains that are compatible with plans for the new HRTs:
  - Westward extension of Platforms 1 and 2 (Alt 14).
  - PSCE - Eastern and western extension of Tracks 1-4 (Alt 15). Previously developed to 30% under the Penn Station Capacity Enhancement (PSCE) Project.

To provide a potential approach to incremental investment that would improve capacity at PSNY, this effort developed the track layout for the westward extension of Platforms 1 and 2 (Alt 14) and the new platform (Alt 12) in combination to ensure that the alternatives are compatible and that they both could be advanced. It is important to highlight that the track alignment developed would disconnect Tracks 1-3 from the “U” and “M” Ladders to enable their westward extension and would connect them to new “T” and “R” Ladders that would

provide access to existing "X" Tracks and, therefore, to both the existing North River Tunnels (NRT) and the planned HRT.

Building a new platform under 31st Street as proposed in Alt 12 and 13 would provide meaningful additional train, platform, and track capacity at PSNY and an opportunity to provide new pedestrian access and vertical and horizontal circulation. Moreover, these concepts would potentially support 2&1 operations to rehabilitate the NRT post HRT completion. The proposed new platform in Alt 12 would be located directly south of Track 1 and in the same east/west location as the existing PSNY platforms. The proposed new platform location would avoid major impacts on the historic St. John the Baptist Church, the Affinia hotel, and the 7th Avenue Subway, which would be required with Alt 13. In addition, Alt 12 would build a new concourse located above the new platform that would provide connections to and improve circulation between the Exit Concourse, the planned extension of the Central Concourse, and the NJ TRANSIT East End Concourse. Furthermore, the new platform would also be connected to an extension of the West End Concourse and to new entrances south of 31st Street. These connections would significantly improve pedestrian circulation, egress capacity, and connectivity both within the station and to the overlying street network.

Extending Platforms 1 and 2 as proposed in Alt 14 and 15 would provide additional trans-Hudson seat capacity, greater flexibility for platform assignments, and a potential reduction of current operational conflicts. In addition, these conceptual alternatives would provide a new connection between Platforms 1 and 2 to and the West End Concourse. The track alignment proposed in Alt 14 would disconnect Tracks 1-3 from the "U" and "M" Ladders to enable their westward extension and would connect them to new "T" and "R" Ladders that would provide access to existing "X" Tracks and, therefore, to both the existing NRT and the planned HRT. The westward extension of platforms 1 and 2 proposed (Alt 14) would allow these platforms to support 12-car train consists without having to underpin the 7th Avenue Subway or impact the 11 Pennsylvania Plaza building which were part of the scope of the PSCE alternative (Alt 15) and would provide new pedestrian connections to an extension of the West End Concourse and the Exit Concourse.

Both Alts 12 and 14 would require significant modifications to the existing track layout at PSNY, including the realignment and removal of several tracks in "D" and "E" Yards, reconfiguration of portions of Platforms 1 and 2, and elimination of the the Diagonal Platform. The new trackways would also require the relocation of numerous columns within the Farley Building footprint. In addition, the westward extension of Platforms 1 and 2 (Alt 14) would require the relocation of several columns that support 8th Avenue and the 8th Avenue Subway. Building the new platform (Alt 12) would require the complete removal of approximately 1,100 linear feet of the south retaining wall and underpinning of the 8th Avenue Subway and several buildings on the north section of Blocks 780 and 754.

Since these two alternatives would not be compatible with the Amtrak PSE concept as currently designed, the PCIP Study also developed a conceptual track alignment for a revised PSE concept that could be implemented in combination with proposed alternatives, 12 and 14.

Infrastructure alternatives Alt 13 and 15, while developed outside of this project, were included in the Phase 2 evaluation for comparison purposes. Minimal modifications were required to the track layout proposed by these two alternatives; therefore, it is expected that if these two

alternatives are advanced, their track alignment and track connections would be revised and optimized.

The two infrastructure alternatives developed in the PCIP study, Alt 12 and Alt 14, were evaluated and compared to alternatives previously developed, namely the construction of one new platform as an initial phase of the PSE concept (Alt 13) and the PSCE extension of Tracks 1-4 (Alt 15) respectively. Order-of-magnitude cost estimates and conceptual schedules, both found in Appendix C, were prepared to support the multicriteria evaluation process. The order-of-magnitude cost estimate for the alternatives that proposed to build a new platform, Alts 12 and 13, are approximately $767 Million and $794 Million respectively and the total duration to complete these projects was estimated at approximately seven years for Alt 12 and eight years for Alt 13. Regarding the extension of Platforms 1 and 2, the order-of-magnitude cost estimate for Alt 14 is approximately $252 Million while for Alt 15 it is approximately $278 Million. The total estimated duration to implement these alternatives is approximately five years for Alt 14 and four and a half years for Alt 15. These order-of-magnitude cost estimates are exclusive of costs associated with real estate acquisition, buildings demolition and underpinning, rolling stock costs and finance costs and include the projected escalation to midpoint of construction for each respective alternative. If these were included, the final project costs are expected to be significantly higher.

In addition, a "parallel moves" analysis was performed on combinations of the infrastructure alternatives including the potential future PSE to assess the operational flexibility these alternatives would provide to support simultaneous train moves to and from New Jersey. The results of this analysis indicated that the alternatives selected would provide a track layout that would support between 92% and 94% of all possible parallel moves depending on the specific alternative.

The results of the overall evaluation analysis indicated that while the implementation of any of the infrastructure alternatives considered would be challenging and would result in disruptions in service and impacts, there are feasible options to improve capacity at PSNY in the near-term. The evaluation analysis rated the proposed westward extension of Platforms 1 and 2 developed in the PCIP Study (Alt 14) higher than the platform extensions proposed in the PSCE project (Alt 15). This was due to the longer train consists that would be supported (which would provide additional train seat capacity), the improved connection to the West End Concourse provided, and the elimination of impacts to systems facilities beyond the eastern limits of the existing platforms, the 7th Avenue Subway and the 11 Pennsylvania Plaza Building.

Despite the higher expected impact to operations during implementation and the significant modifications on the existing track layout, the proposed alternative to build a new platform developed in the PCIP Study (Alt 12) was rated higher than the initial phase of the Amtrak PSE design (Alt 13). This was primarily due to the reduced constructability challenges, better design criteria compatibility, and the location of the new platform, which minimized impacts to existing historic buildings and the 7th Avenue Subway.

Operations Alternatives

Regarding the operations alternatives, the two selected alternatives would improve capacity with relatively small infrastructure modifications and could be implemented in the near term. The two selected operations alternatives are:

- Two operations alternatives to improve capacity with relatively small infrastructure modifications that could be realized with or without new HRTs:
  - Alt OP1: Reduction of the minimum NJ TRANSIT revenue-to-revenue train dwell time to 18 minutes.
  - Alt OP2: "X" Tracks improvements to increase maximum entering speed to 30MPH.

The reduction of the minimum NJ TRANSIT revenue-to-revenue turn time from the current 22 minutes to 18 minutes (Alt OP1) could increase platform capacity by 17% (from a combined Amtrak/NJ TRANSIT 26 TPH to a combined 30TPH) based on the track assignment analysis conducted. The proposed reduction on the existing dwell time was determined in close coordination with NJ TRANSIT and was based on observations of routine practices, common challenges and problems related to reliability and station crowding, and incident management. The analysis conservatively assumed that no two revenue trips would alight on the same platform within five minutes of one another to reflect the recognition that limited passenger vertical circulation improvements were likely in the near term.

Based on the trans-Hudson and PSNY Terminal Capacity high-level analysis performed, the trans-Hudson capacity provided by the HRT would be required to realize the terminal capacity gain that would be provided by the proposed reduction of the minimum NJ TRANSIT revenue-to-revenue train dwell time. Without HRT, this terminal capacity gain could not be realized given the 24 TPH trans-Hudson capacity limitation of the existing NRT; however, the reduction in NJ TRANSIT revenue-to-revenue turn time would provide an available terminal capacity gain that would improve both reliability and recoverability in the event of train delays.

The "X" Tracks improvements proposed (Alt OP2) would replace the existing No. 10 turnouts near the NRT portal with No. 12 turnouts and would extend ACSES II PTC coverage to the normally eastbound X tracks – 1X, 2X, and 3X to allow for increased approach speeds of 30 MPH (dropping to a target speed of 15 MPH once trains entered the "X" Tracks). It is estimated that this would enable an increase in the practical capacity of the existing NRT eastbound volume by 2 TPH to a total of 26 TPH and would likely have a positive impact on reliability. Considering that the current platform capacity at PSNY has been estimated at 26 TPH based on current scheduled minimum turn times, the implementation of the "X" Tracks improvements would realize an overall capacity gain of 2 TPH. The feasibility and issues associated with the PTC implementation would require further review.

A PSNY terminal capacity preliminary analysis was also carried out to compare the platform capacity benefits anticipated for the proposed infrastructure-oriented alternatives with the trans-Hudson capacity achievable under operations alternatives with and without HRT.

The main key findings of this analysis were that:

- If the 18-min revenue-to-revenue turn time alternative (Alt OP1) is advanced, then one additional maximum length track (such as Track 10) would be available for additional flexibility and enhanced reliability. Moreover, the number of new platforms required in the long term to meet NRT and HRT trans-Hudson capacity would be reduced.
- If the X-Tracks Improvements alternative is advanced (Alt OP2) and the 22-minute revenue-to-revenue turn time is maintained, then no new platform edges would be required to meet NRT trans-Hudson capacity, but existing spare platform track availability would be eliminated.

It is anticipated that the two operations-oriented alternatives considered would be easier to implement relative to the infrastructure-oriented alternatives, primarily because there would be no impacts to adjacent properties and relatively minor capital costs. Nevertheless, the 18-minute revenue-to-revenue dwell time alternative would require considerable changes to existing operating practices with significant recurring costs for larger Operations and Maintenance staffing at NJ TRANSIT. The "X" Tracks improvements proposed would have a considerable impact to train operations during implementation due to the critical area of construction and would require complex eastward expansion of the existing Amtrak ACSES II Positive Train Control (PTC) system. Implementation of either of the operational alternatives would require significant effort to secure internal stakeholder buy-in. Further, the relatively modest PSNY capacity gains would be subject to negotiations with Amtrak regarding how the additional train slots are allocated between NJ TRANSIT and Amtrak.

Conclusions

The PCIP exploratory planning effort identified feasible conceptual alternatives that could be pursued to provide a modest amount of PSNY capacity and reliability relief in the near-term while planning, funding, and construction is in progress for the larger Gateway initiatives and possible significant capacity expansion of PSNY. The infrastructure and operations alternatives identified and described in this Final Report have the potential to increase capacity and reliability at PSNY in the near-term, which was the primary goal of this project. While the modifications proposed to existing infrastructure and current operations offer significant potential benefit, implementing them would have significant impacts and costs and would require a rigorous approvals process. Further study, analysis and coordination with the main stakeholders is required to refine the engineering, constructability, and accrued train/passenger capacity gains to properly consider implementation requirements. The PCIP Study has shown that the potential significant benefit these alternatives offer warrants this additional study.

Given the conceptual level of this effort, significant additional study, investigation, development and coordination would be required to move these alternatives forward. Next stages of design should further consider important items such as rail operations, traction power/catenary, communications and signaling, structural impacts, ventilation, fire-life safety, property acquisition, permitting, environmental sensitivities, construction phasing and funding opportunities. Finally, this report has proposed a series of next steps proposed to provide suggestions on strategic actions that can be taken to advance planning for the alternatives selected through this study to increase PSNY capacity in the near term.

Appendix A: Engineering Drawings

Appendix B: Structural Appendix

B1. Building Underpinning Conceptual Approach

B2. Amtrak Building Underpinning Conceptual Approach

B3. 8th Avenue Subway Columns Relocation and Underpinning

B4. PSNY Impacted Column Relocations

Appendix C: Conceptual Cost Estimating, Schedule and Qualitative Risk Considerations

Appendix D: Preliminary Alternatives Development and Evaluation – Sketch Concepts

Appendix E: PCIP Document Catalog – User Guide

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