THE NORTHWEST SEAPORT ALLIANCE
SEATTLE + TACOMA

Terminal 5 Uplands Modernization and Rehabilitation Project Final Phase

U.S. DEPARTMENT OF TRANSPORTATION – MARITIME ADMINISTRATION
Port Infrastructure Development Program (PIDP)
Opportunity Number 693JF7-20-BAA-0001

APPENDIX B3

BENEFIT COST ANALYSIS REPORT

THE NORTHWEST SEAPORT ALLIANCE

Benefit Cost Analysis Report

Terminal 5 Uplands Modernization and Rehabilitation Project

Final Phase

U.S. Department of Transportation – Maritime Administration

Port Infrastructure Development Program (PIDP)

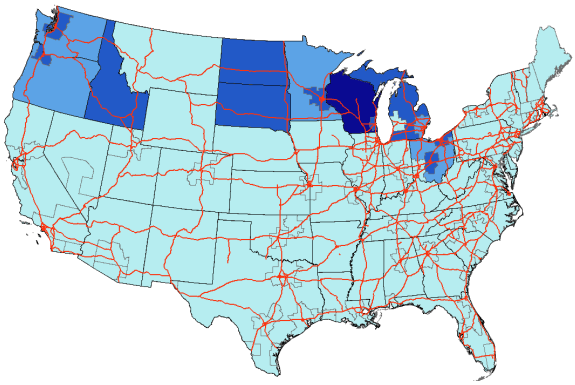
Opportunity Number 693JF7-20-BAA-0001

I. Summary

Terminal 5 (T-5) Benefit Cost Analysis (BCA) evaluates the cost savings, congestion reductions, safety benefits, and emissions reductions of the commissioning of the Terminal 5 Uplands Modernization and Rehabilitation Project Final Phase (T-5 PROJECT) by the Northwest Seaport Alliance (NWSA).

The goal of the T-5 PROJECT is to accommodate larger ships, up to 18,000 TEUs, similar to other major West Coast ports. Allowing for these larger ships to call at T-5 will equalize the ocean transportation costs on the import and export side compared to competing ports, and lead to optimization of inland cargo flows based on lower inland transportation costs. This optimization would increase market penetration of NWSA in the Northwest, Mountain, and Upper Midwest states stretching from Idaho to Michigan (Figure 1).

Figure 1: Change in the import market share due to commissioning of T-5 PROJECT



Market share gains are projected to most likely occur for Asian cargo originating from/terminating in inland areas closer to NWSA than other West Coast ports. This market share change is expected to lead to an ultimate annual increase of approximately 776,000 TEUs in NWSA's volumes (import and export). This change in freight flows is expected to lead to average annual net saving of 871 million miles for truck and 9.1 billion ton-miles for rail transportation associated with the movement of containers. The mileage reduction is a function of NWSA gaining share in Northwest and Upper Midwest markets which are currently being serviced by more distant West Coast ports. The T-5 PROJECT will also lead to reduced use of diesel generators on site, along with avoided construction period interruptions that would otherwise be caused by installing stormwater management equipment at the terminal.

These benefits have significant national benefits in terms of transport cost reductions, pavement damage reductions, crash reductions for trucks and rail, air pollution reductions, and operation and maintenance related savings. Based on anticipated benefits for each of these categories, we expect that the T-5 PROJECT will generate a **net present value (NPV) of $1.07 billion** at a 7% discount rate, along with an exceptionally strong **benefit to cost ratio of 3.796**.

Table 1: Summary of Costs, Benefits, and Net Present Value, and Benefit Cost Ratio

Cost or Benefit Category	Total Value (7% Discount)
Truck Freight Cost Savings	$638,686,425
Rail Freight Cost Savings	$168,102,094
Truck Pavement Damage Reduction	$21,658,188
Truck Crash Reduction & Alleviated Loss of Life	$549,712,731
Rail Crash Reduction	$425,601

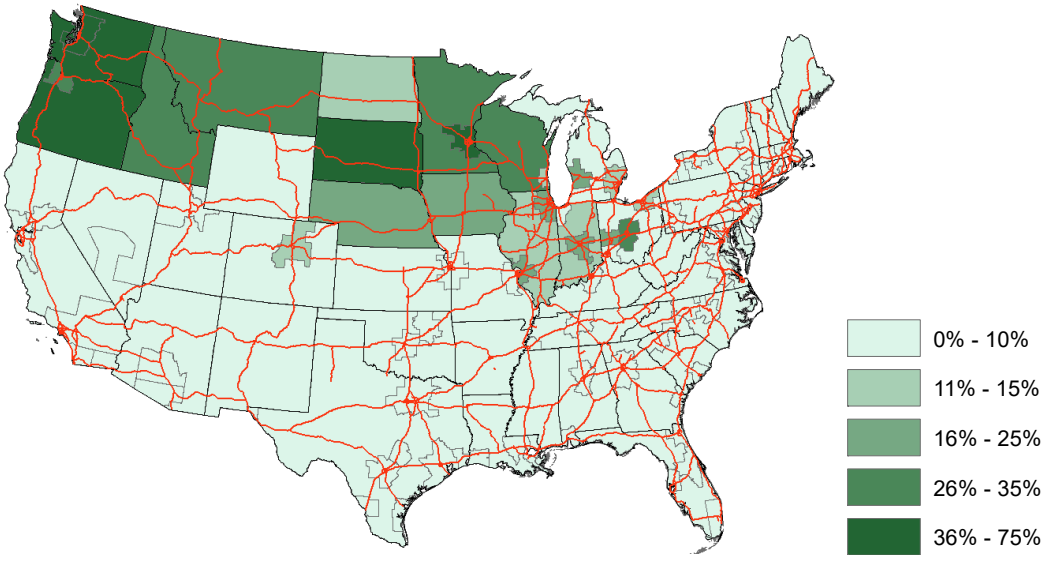
Cost or Benefit Category	Total Value (7% Discount)
Truck Air Pollution Reductions	$26,725,301
Rail Air Pollution Reductions	$19,593,336
Reefer Air Pollution Reductions	$1,277,533
Operations and Maintenance (net benefit versus baseline)	$23,893,811
Total Capital Costs	$382,035,979
NET PRESENT VALUE	**$1,068,039,041**
BENEFIT COST RATIO	**3.796**

II. Benefit Cost Analysis

Base Case

- NWSA, in implementing the T-5 Modernization Program (T-5 PROGRAM) does not complete or commission the activities proposed under this application for the T-5 PROJECT and therefore cannot complete the full overarching T-5 PROGRAM.
    - T-5 can only service limited capacity due to insufficient pavement, rail limitations, and other on site limitations, described in the project narrative.
    - NWSA will maintain or experience a decreased market share in inland markets.
    - Port volumes will continue to grow organically.
    - Canadian competition will continue to threaten NWSA's market area, particularly in the Midwest states.
    - Operations at T-5 will increase slowly, consistent with site limitations.

Figure 2: *NWSA Base Case Import Market Share*



Source: USATrade Online, Freight Analysis Framework

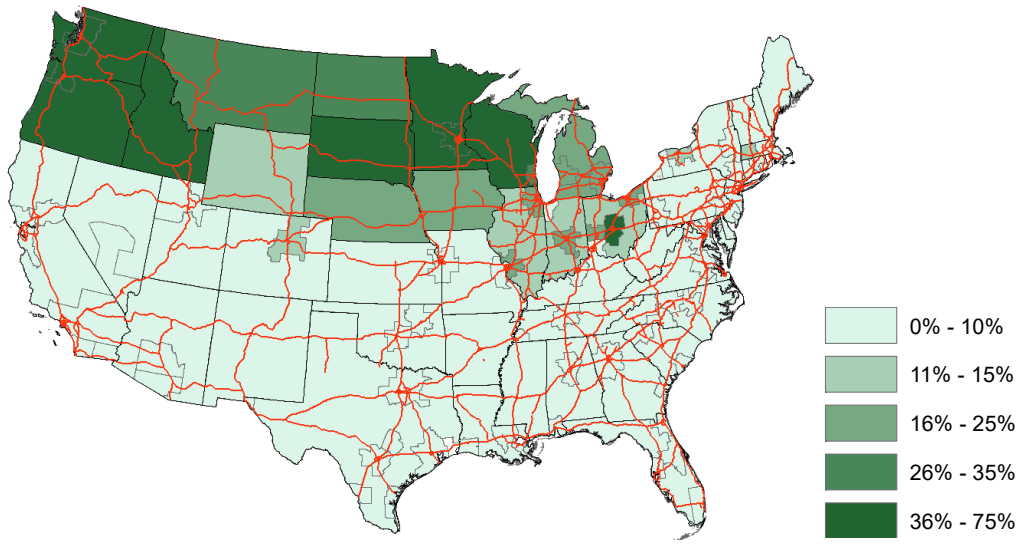
T-5 Modernization Case

- NWSA completes the proposed project and the full T-5 PROJECT.
    - Key on site infrastructure issues including pavement and train related limitations are alleviated.

- The expansion also allows T-5 to accommodate larger ships of up to 18,000 TEUs, similar to other major West Coast ports.
- These larger ships will equalize the ocean transportation costs of NWSA on the import and export side compared to other competing ports, particularly in British Columbia
- This equalization of ocean costs would make it more cost effective for Northwest, Mountain, and Upper Midwest areas to be served by NWSA than other competing ports since they would be closer (in terms of truck and rail miles) to NWSA.
- This cost effectiveness would encourage cargo owners to shift their port of entry/departure for Asian cargo from other west coast North American ports to NWSA and lead to reduction in total rail and truck miles travelled and optimize inland cargo flows.

- This optimization would increase market penetration of NWSA in Northwest, Mountain, and Upper Midwest states stretching from Idaho to Michigan, as denoted by the more pervasive darker shades of green Figure 3.
- The analysis assumes that terminal handling charges, which are used to pay for the operating and maintenance (O&M) costs of the facility, will remain the same for the base and alternate cases. Since there is no change in base and alternate case terminal handling charges, these costs and their uses are not part of this analysis.

Figure 3: *NWSA Alternate Case Import Market Share*



Source: USATrade Online, Freight Analysis Framework

Key Parameters and Assumptions

The analysis incorporates various assumptions and key parameters relevant to the overall results. Key parameters are summarized in the following table, along with applicable sources. For additional detail, please refer to the BCA model, which is attached to this application as an excel file.

Table 2: Summary of Key Parameters and Assumptions

Parameter	Value	Notes; Source
Truck Freight Costs	$ 1.821/mile	Includes driver costs; CURRENT https://truckingresearch.org/wp-content/uploads/2019/11/ATRI-Operational-Costs-of-Trucking-2019-1.pdf
Rail Freight Costs	$0.04021/ton-mile	https://www.bts.gov/content/average-freight-revenue-ton-mile
pavement, urban congestion, urban noise, urban pavement, rural congestion, rural noise, rural Crash cost, Urban 5-axle Crash cost, Rural 5-axle Loss of life from crashes, urban Loss of life from crashes, rural Value of a statistical life	$0.109680 $0.186817 $0.027936 $0.034471 $0.019638 $0.001776 $0.880000 $1.150000 0.86 1.70 $9,600,000	Updated from 2002$ to 2019$ using DOT suggested multiplier; https://www.fhwa.dot.gov/policy/hcas/addendum.cfm Train only: https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/workingpaper/50049-Freight_Transport_Working_Paper-2.pdf
% distance urban % distance rural	30% 70%	Assumed based on review of travel routes
Truck Fuel Economy	5.9 miles/gallon	https://www.bts.gov/content/combination-truck-fuel-consumption-and-travel (Table 4-14)
Air Emissions per mile, trucks NOx VOCs PM2.5 SO2 CO2	 4.5819 g/mile 0.4051 g/mile 0.0331 g/mile 0.0149 g/mile 22.4 lb/gallon	GREET Model Emission Factors, Table A22 for long haul diesel trucks; CO2 from: https://www.eia.gov/environment/emissions/co2_vol_mass.php
Air Emissions Costs/Savings NOx VOCs PM2.5 SO2	 $8,300/ton $2,000/ton $377,800/ton $48,900/ton	BCA Guidance Documentation
Rail: Tons per Mile	18 ton-miles	Assumption
Air Emissions, g/bhp-hr, locomotives, Assumes Tier IV NOx VOCs PM2.5	 1.30 g/bhp-hr 0.140 g/bhp-hr 0.006 g/bhp-hr	https://nepis.epa.gov/Exe/ZyPDF.cgi/P100500B.PDF?Dockey=P100500B.PDF
Fuel Consumption, Rail	400 ton-mile/gallon	US Average per USEPA: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100500B.PDF?Dockey=P100500B.PDF
Discount Rate	7%	BCA Guidance
T-5 Modernization at Capacity	1,300,000 TEU	Project Description
T-5 Maximum Realistic Capacity Factor	80%	Project Description
Project construction period considered in model	2021 to 2024	Assumption
Project operation period considered in model	Through 2045	Assumption

Methods

We completed a benefit cost model for the baseline T-5 PROGRAM and the proposed T-5 PROJECT cases described previously. Note that, for reviewer convenience, we have provided a separate BCA spreadsheet for the base case implementation of the Program without the T-5 PROJECT, as well as full T-5 PROGRAM implementation with the T-5 PROJECT. The remaining discussion in this document focuses on results of the full BCA, which considers the T-5 PROJECT as a final element of the overarching Program. Please refer to the Narrative for additional details. The full model is attached, and was completed in full compliance with BCA guidance provided by DOT. Briefly, the analysis considers the costs and benefits of fully implemented T-5 PROGRAM (inclusive of the T-5 PROJECT) less the benefits and costs of the no build scenario. Costs included all project capital costs, accrued according to the anticipated construction schedule. The no build scenario would not include implementation of any T-5 PROJECT specific elements. These were included as operations and maintenance (O&M). Other O&M costs were considered for each of the T-5 PROJECT scenario elements, and for all relevant baseline scenario O&M costs. These can be reviewed on the 2_MODEL_Costs worksheet.

The BCA evaluates the freight transit mileage reductions and associated cost savings from freight costs, pavement damage reduction (trucks only), improved safety/reduced crashes/reduced loss of life from crashes, and air pollutant emissions reduction. The BCA also evaluates emissions reductions associated with reefer electrification and considers the work zone benefits of completing the proposed stormwater improvements at present, before site operation ramps up, rather than during ongoing operations under the base case scenario. Note that routing of freight through T-5 rather than through competing ports will increase market penetration of NWSA in the PNW and Mountain / Upper Midwest states stretching from Idaho to Ohio, while reducing freight trucking and rail shipping needs versus managing cargo through major ports in Canada, and other west coast ports. This optimization will leverage the lower costs of ship-borne transport available through the modernized terminal.

Briefly, the BCA considers the following elements:

Freight Transport Reduction; Truck and Rail Distances: Freight flows were evaluated by combining data from USATrade Online and Freight Analysis Framework (FAF) to estimate NWSA's market share from different inland markets. Then, Oak Ridge National Laboratory's County-to-County Distance Matrix[1] was used to calculate the savings in truck and rail miles.

Truck Pavement Damage Reduction, Truck Crash Reduction, Rail Crash Reduction: Main components were taken from the "Addendum to the 1997 Federal High Cost Allocation Study Final Report" provided by the Federal Highway Administration (FHWA) and "Pricing Freight Transport to Account for External Costs" provided by the Congressional Budget Office (CBO) for truck and rail, respectively. For truck costs, highway travel was assumed to take place on rural-urban highways with a 70%-30% split, found by using total miles from the Bureau of

[1] http://cta.ornl.gov/transnet/SkimTree.htm

Transportation Statistics[2]. Rail accident risk cost per mile was sourced from data available through the Congressional Budget Office.[3] These costs were adjusted with inflation using 2020 as the base year.

Rail Costs: Estimated based on data from USRailDesktop[4] by averaging the per mile cost of shipping containers with the Burlington Northern Santa Fe (BNSF) and Union Pacific (UP) rail roads

Truck Costs: Truck costs are derived from the report "An Analysis of the Operational Costs of Trucking: 2019 Update"[5] by the American Transportation Research Institute (ATRI) and are based on a per mile basis and adjusted for inflation and changes in fuel prices.

All Operations and Maintenance Costs were estimated based on a combination of historic (i.e., prior to 2014) operations at T-5 and/or costs at the adjacent Terminal 18. All O&M costs were verified by technical staff and/or management staff at the port and/or SSA Marine.

All Capital Costs were assembled based on preliminary quotes and other sources, as documented in the full grant application for this project.

Project Impact

Output from the BCA indicates, consistent with prior market studies completed by NWSA, that the incremental demand generated based on optimization of freight flows would vary over time, but would be about 786,000 TEUs per year by the end of the projection period, served with up to an 18,000 TEU service, between Asia and North America (Figure 4). Note that throughput under the T-5 Modernization scenario flattens once operations reach 80% of capacity. This effective cap was included based on guidance from port operational managers and engineers, who indicated that operating the system over 80% could be done over short periods, but that congestion under such cases makes effective and efficient operation difficult.

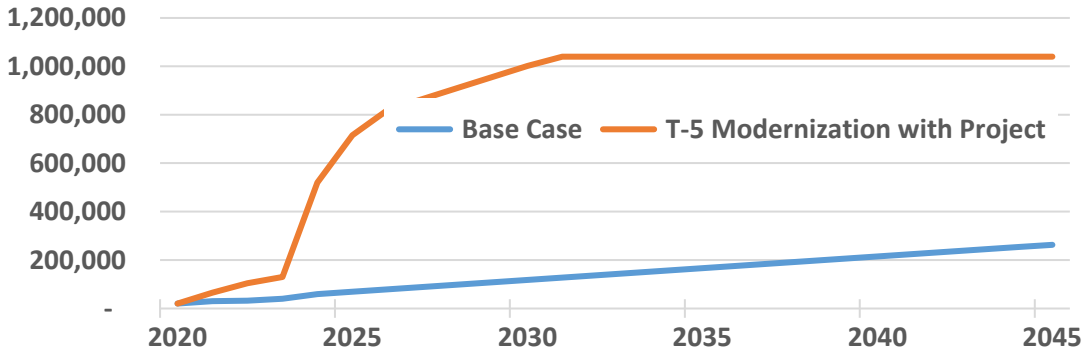
[2] http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_06.html

[3] https://www.cbo.gov/sites/default/files/114th-congress-2015-2016/workingpaper/50049-Freight_Transport_Working_Paper-2.pdf

[4] http://www.usraildesktop.com/

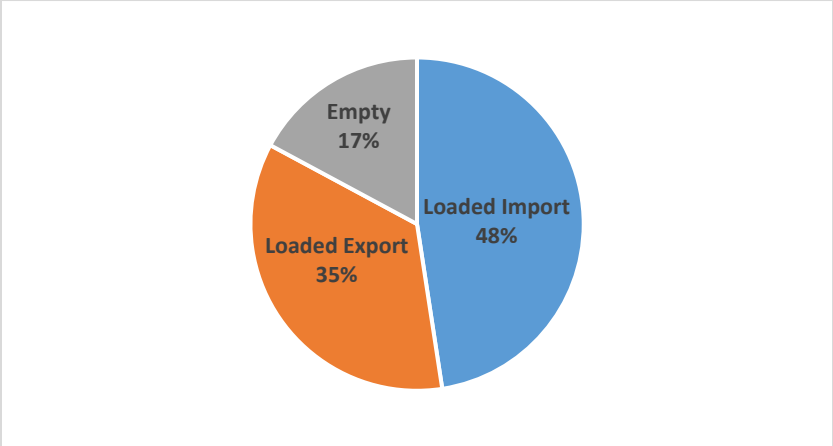
[5] CURRENT https://truckingresearch.org/wp-content/uploads/2019/11/ATRI-Operational-Costs-of-Trucking-2019-1.pdf

Figure 4: TEU Forecasts for Base Case and Alternate Case



Future volume breakdown is expected to remain close to NWSA's 2010-2019 average break down of 48%, 35% and 17% for loaded import, loaded export and empty containers export, respectively (Figure 5). Note that TEU volumes and projections for loaded import/export and empty containers are based on historic data from the American Association of Port Authorities (AAPA) and Mercator forecast in Strategic Vision for the Puget Sound Gateway 2015-2025 (March 10, 2015)

Figure 5: Container Type Share of Total TEUs, 2010-2019



Source: Association of Port Authorities (APPA), Mercator

Rerouting of freight flows through new available capacity at T-5 is expected to lead to the following average annual savings in truck and rail miles for domestic container trade:

- Truck Miles Savings: 871,199,234
- Rail Ton-Miles Savings: 9,166,555,320 (i.e., approximately 509,253,073 rail miles)

Note that truck miles are estimated to be split approximately 70% rural and 30% urban, where relevant (see Methods). The reduction in truck and rail miles was calculated by using the increase in TEUs flowing through NWSA, which in turn would reduce the total transport miles needed to ship containerized goods from competing West Coast ports. The target markets served

by NWSA are located within shorter truck and/or rail miles from NWSA, in comparison to other West Coast ports, creating mileage reductions in transporting freight.

Table 3: Total Reduction in Total Freight Miles

Cost or Benefit Category	Mileage Reduction	Total Savings (7% Discount)
Truck Freight Reduction	871,199,234 miles	$638,686,425
Rail Freight Reduction	9,166,555,320 ton-miles (equivalent to 509,253,073 rail miles)	$168,102,094

The value of mileage reductions was calculated using the truck and rail freight costs were calculated using the values shown in Table 2, and then discounted at a 7% rate. Truck freight costs include costs labor and associated driver costs, in addition to costs of the truck itself. Note that transportation cost savings are estimated using only the cost of laden containers while social costs are estimated based on both laden and empty movements.

The T-5 PROJECT also resulted in emissions reduction for multiple pollutants including nitrogen oxides (NOx; 6,228 tons reduction), volatile organic compounds (VOCs; 607 tons), fine particulate matter (PM2.5; 47 tons), sulfur dioxide (SO2; 19 tons), and carbon dioxide (CO2; 29.6 million tons). Collectively, these emissions reduction benefits will support $47.6 million in emissions reduction benefits (discounted at 7%), based on the air emissions savings valuations provided in the BCA guidance documentation (see also Table 2). These benefits are derived primarily from truck and train freight reductions, but also from reduced diesel consumption on site, due to the use of the proposed reefer electrification system under the T-5 PROJECT (see model worksheet *Results Charts* for additional detail).

Table 4: Total Air Emissions Benefits

Cost or Benefit Category	Air Emissions Reduction	Total Savings (7% Discount)
Pollutant Emissions Reduction		$47,596,170
NOx	6,228 tons	
VOCs	607 tons	
PM2.5	47 tons	
SO2	19 tons	
CO2	29.6 million tons	

Other identified benefits also considered truck and rail miles incurred when travelling empty, in addition to loaded miles. Results indicate crash reduction and loss of life benefits at $550 million (discounted at 7%), based on the crash cost values provided in Table 2. The T-5 PROJECT also supported pavement damage reductions from reduced trucking ($22 million discounted at 7%), calculated by multiplying mileage savings by the relevant cost figure provided in Table 2. Per DOT guidance, net operations and maintenance costs were counted against total net benefits. Due to newer infrastructure and reduced stormwater costs, the T-5 PROJECT scenario resulted in a total net *benefit* of $24 million when discounted at 7% (Table 5). Note that lost operational

capacity due to stormwater system installation under the base case was accounted for by a temporary freight capacity reduction (5%) in the base case, during model years 2025 and 2026.

Table 5: Summary of All Net Benefits and Costs

Net Present Value and Benefit Cost Ratio Calculations Summary	
Cost or Benefit Category	**Total Value (7% Discount)**
Truck Freight Cost Savings	$638,686,425
Rail Freight Cost Savings	$168,102,094
Truck Pavement Damage Reduction	$21,658,188
Truck Crash Reduction & Alleviated Loss of Life	$549,712,731
Rail Crash Reduction	$425,601
Truck Air Pollution Reductions	$26,725,301
Rail Air Pollution Reductions	$19,593,336
Reefer Air Pollution Reductions	$1,277,533
Operations and Maintenance (net benefit versus baseline)	$23,893,811
Total Capital Costs	($382,035,979)
NET PRESENT VALUE	**$1,068,039,041**
BENEFIT COST RATIO	**3.796**

Based on these numbers and on total costs for deploying and operating the T-5 PROJECT, final results of the BCA show an exceptionally strong **net present value (NPV) of $1.07 billion**. This NPV will be equivalent to a benefit cost ratio (**BCR**) of 3.796. Therefore, T-5 PROJECT implementation, when considered alongside other T-5 PROJECT scenario elements, will provide exceptional return on DOT's investment. For additional information on the BCA, please refer to the associated spreadsheet file.

Figure 6: T-5 Modernization Scenario Net Costs and Benefits Summary, with NPV