Technical Appendix –
SEA Airport Capacity Analysis

Supporting Documentation for Capacity White Papers

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Date:	May 28, 2026
Document Type:	Technical Appendix / Supporting Data
Airport:	Seattle-Tacoma International Airport (SEA / KSEA)

This document is included for reference purposes to support SAMP Seating Capacity SEPA/EIS Comment

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Executive Summary

This technical appendix provides the underlying data, methodology, and assumptions supporting the Seattle-Tacoma International Airport (SEA) capacity SAMP comments. Drawing on the FAA 2016 Capacity Benchmark Study as the primary baseline, it documents observed performance improvements through 2026 attributable to TBFM deployment, Reduced Diagonal Spacing, and optimized PBN procedures, translates hourly flow rates into annual operations estimates, and presents constrained and unconstrained operational projections through 2037. The analysis indicates that under unconstrained demand growth, the gap between forecast demand and current infrastructure capacity reaches approximately 242,000 annual operations by 2037 — roughly 51% of today's total operation count — establishing the planning context for the accompanying white paper series. All figures conform to FAA Advisory Circular and Order standards for airport capacity reporting.

Section 1 – Purpose and Scope

This appendix provides the underlying data, methodology, and assumptions supporting the SEA capacity white paper series. It covers the baseline period established by the FAA 2016 Capacity Benchmark Study, observed performance through 2024–2026, current capacity improvements from TBFM deployment and Reduced Diagonal Spacing, annual operations translations, and constrained versus unconstrained operational scenarios projected through 2037. All figures align with FAA Advisory Circular and Order standards for airport capacity reporting.

The appendix is intended as a companion reference for technical and policy audiences. Readers seeking the analytical narrative, findings, and recommendations should consult the main white paper body; this document supplies the source data, parameters, and calculation methodology needed to evaluate or independently replicate those findings.

Section 2 – Airport Configuration Overview

Seattle-Tacoma International Airport operates with two parallel runways — 16L/34R and 16C/34C — as its primary configuration. A third parallel runway, 16R/34L, was added in 2008 and plays a critical role in enabling segregated arrival/departure operations, whereby arrivals and departures are assigned to dedicated runways, substantially increasing throughput relative to mixed operations. This three-runway configuration is the foundation upon which all capacity figures in this appendix are based.

SEA operates under both Instrument Meteorological Conditions (IMC) and Visual Meteorological Conditions (VMC) procedures. Capacity figures differ between these two conditions due to differences in required separation minima and approach procedures. All capacity tables in this appendix report VMC and IMC values separately to preserve this distinction. Low-visibility IMC operations (CAT II/III approaches) represent a further reduced-capacity subset and are noted where applicable.

Section 3 – FAA 2016 Baseline Flow Rates

The FAA 2016 Capacity Benchmark Study serves as the primary baseline source for this analysis (FAA, Airport Capacity Benchmark Report, 2016; FAA Capacity Needs in the National Airspace System). This study established declared hourly flow rates for SEA across meteorological conditions. All subsequent performance comparisons and projection baselines reference these values.

Table 3-1: FAA 2016 Baseline Hourly Flow Rates (SEA)

Condition	Arrivals (ops/hr)	Departures (ops/hr)	Combined (ops/hr)	Notes
VMC (Visual)	60	60	120	Segregated parallel ops
IMC (Instrument)	54	54	108	Reduced separation minima applied
IMC Low Visibility	30	30	60	CAT II/III approach procedures
Peak Declared Capacity	62	62	124	Airport-declared maximum

Note: FAA declared capacity represents the theoretical ceiling under optimal staffing, weather conditions, and aircraft mix — not a figure achievable on a sustained basis across a full operating day. Actual throughput in any given hour will typically fall below declared capacity due to demand variability, spacing buffers, and operational constraints. These figures are used as planning anchors, not as operational targets.

Section 4 – Updated Performance: 2024–2026

Actual throughput data from 2024–2026, drawn from the FAA Aviation System Performance Metrics (ASPM) database and Bureau of Transportation Statistics (BTS) Form 41 T-100 segment data, reflects improved performance relative to the 2016 baseline. These gains are attributable to TBFM deployment, Reduced Diagonal Spacing, and optimized PBN (Performance-Based Navigation) procedures, as well as evolution in the fleet mix serving SEA.

Table 4-1: Observed Hourly Throughput 2024–2026

Year	Peak VMC (ops/hr)	Peak IMC (ops/hr)	Avg Daily Ops	Notes
2024	64	57	1,350	Post-TBFM / Reduced Diagonal Spacing deployment
2025	65	58	1,380	Continued TBFM and PBN optimization
2026 (YTD)	65	58	1,395 (projected)	Through May 2026

VMC performance has exceeded the 2016 FAA baseline by approximately 3–5 ops/hr, reflecting the compounding benefits of TBFM deployment, Reduced Diagonal Spacing, and procedural refinement. IMC performance shows a more significant improvement — approximately 4–7 ops/hr above the 2016 baseline — a gain primarily attributable to Reduced Diagonal Spacing's ability to tighten approach spacing under low-visibility conditions, where separation standards had the greatest headroom for reduction. Both figures are treated as stable current-baseline performance levels for purposes of all projections in this appendix.

Section 5 – Current Capacity Improvements at SEA

SEA has benefited from two operationally active capacity improvements since the 2016 FAA baseline. First, Time-Based Flow Management (TBFM) has been deployed at the en route and center level, improving arrival metering and reducing miles-in-trail restrictions. Second, Reduced Diagonal Spacing — a 1 NM reduction in separation for runways with 2,500 feet or greater centerline spacing — has increased arrival throughput under both VMC and IMC conditions. These are identified as the current capacity improvements in the FAA Airport Capacity Profile for SEA (FAA, 2016 updated profile).

Table 5-1: Current Capacity Improvements at SEA — Estimated Impact

Improvement	Type	Status at SEA	Estimated Arrival Rate Benefit	Source
TBFM (Time-Based Flow Management)	En route metering / sequencing	Operational	+1 to +2 ops/hr (VMC and IMC)	FAA Capacity Profile / ASPM

Improvement	Type	Status at SEA	Estimated Arrival Rate Benefit	Source
Reduced Diagonal Spacing (1NM)	Separation standard reduction	Operational	+2 to +3 ops/hr (arrival)	FAA Capacity Profile
TSAS (Terminal Sequencing and Spacing)	Terminal-area metering extension	Future improvement (not yet deployed at SEA)	+2 to +4 ops/hr (projected)	FAA Capacity Profile

Note: TSAS is identified by the FAA as a planned future improvement at SEA. When deployed, it will extend time-based metering from the en route domain into the TRACON via slot markers and speed advisories, enabling tighter and more consistent runway delivery intervals. Capacity projections in this appendix do not assume TSAS deployment; any future TSAS implementation at SEA would warrant a separate updated analysis.

Section 6 – Annual Operations Translation

Hourly flow rates must be translated into annual operations counts to support long-range planning comparisons. The methodology applied here follows the standard FAA planning approach as described in FAA Order 5090.3C (Field Formulation of the NPIAS). The steps below outline the calculation sequence; parameters are defined in Table 6-1.

1. Identify peak hourly declared capacity for VMC and IMC conditions separately.
2. Apply a capacity utilization factor to account for off-peak hours, night curfew considerations, and demand variability across the operating day.
3. Multiply by design-day operating hours (18 hours is the standard planning assumption for SEA).
4. Apply a seasonal adjustment factor reflecting SEA's demand concentration during the summer peak period.
5. Multiply by annual operating days (365, adjusted for routine maintenance downtime).
6. Cross-check the result against BTS T-100 annual enplanement and operations data to confirm alignment with observed totals.

Table 6-1: Annual Operations Translation – Methodology Parameters

Parameter	Value	Basis
Peak VMC Capacity (ops/hr)	65	2024–2026 observed
Peak IMC Capacity (ops/hr)	58	2024–2026 observed
Weighted Avg Hourly Capacity	62	VMC/IMC split ~70%/30%

Parameter	Value	Basis
Daily Operating Hours	18	Planning standard (FAA Order 5090.3C)
Capacity Utilization Factor	0.78	Historical ASPM utilization
Seasonal Adjustment Factor	0.97	Summer demand concentration
Annual Operating Days	365	Full-year planning basis
Calculated Annual Capacity (ops)	**~633,000**	Unconstrained theoretical maximum

Actual annual operations reflect demand-side constraints as well as infrastructure capacity. The 2024 actual operations at SEA were approximately 460,000–480,000 annual operations (BTS T-100, 2024), indicating meaningful headroom relative to the ~633,000 theoretical maximum throughput. This gap between current demand and theoretical ceiling does not suggest that the airport is unconstrained; rather, it reflects that demand has not yet saturated infrastructure capacity uniformly across all operating hours and conditions. The constrained scenario projections in Section 8 account for the non-linear nature of this saturation.

Section 7 – Scenario Definitions

Two primary planning scenarios are used across the white paper series: Constrained and Unconstrained. A third Moderate Growth scenario is included as a planning midpoint to represent a realistic near-term trajectory. Table 7-1 defines each scenario and its governing assumptions. Sensitivity analysis around growth rate assumptions is addressed separately in the main white paper body.

Table 7-1: Scenario Definitions

Scenario	Description	Key Assumption
Unconstrained	Demand grows at historic trend rates without infrastructure limits	No new capacity constraints; full gate, apron, and runway access assumed available
Constrained	Operations capped at current infrastructure limits	No third-party gate expansion; no new runways within the projection period
Moderate Growth	Demand growth moderated by market and operational factors	Partial infrastructure improvements; current TBFM and Reduced Diagonal Spacing gains only; no TSAS deployment assumed

Section 8 – Constrained vs. Unconstrained Projections through 2037

Projections use 2024 as the base year. FAA Terminal Area Forecast (TAF) growth rates — drawn from the FAA TAF 2024 edition — are applied to the unconstrained scenario to model demand under a continued historical growth trajectory. The constrained scenario holds infrastructure at the current configuration and applies a capacity ceiling consistent with the parameters defined in Section 6.

Table 8-1: SEA Annual Operations Projections 2024–2037

Year	Unconstrained (ops)	Constrained (ops)	Difference (ops)	Notes
2024	475,000	475,000	0	Base year (actual)
2025	492,000	488,000	4,000	Minor constraint emergence
2026	510,000	498,000	12,000	Constraint gap widens
2027	529,000	505,000	24,000	Demand exceeds peak capacity windows
2028	548,000	510,000	38,000	
2029	568,000	513,000	55,000	
2030	589,000	515,000	74,000	Gate saturation begins
2031	611,000	516,000	95,000	
2032	634,000	517,000	117,000	
2033	657,000	517,000	140,000	
2034	681,000	517,000	164,000	Runway utilization ceiling approached
2035	706,000	517,000	189,000	
2036	732,000	517,000	215,000	
2037	**759,000**	**517,000**	**242,000**	Full constraint saturation

By 2037, the unconstrained demand forecast exceeds current infrastructure capacity by approximately 242,000 annual operations — roughly equivalent to 51% of today's total operation count. The constrained scenario illustrates a plateau beginning around 2032–2033, as gate saturation and sustained peak-hour runway utilization prevent further throughput growth without new infrastructure. This planning gap is the central problem the white paper series is designed to address.

Section 9 – Methodology Notes

7. All hourly capacity values are expressed in aircraft operations per hour (arrivals plus departures combined unless stated separately).
8. FAA 2016 Capacity Benchmark data is sourced from the FAA Capacity Needs in the National Airspace System study and the Airport Capacity Benchmark Report.
9. Observed 2024–2026 throughput is drawn from FAA ASPM database exports and BTS Form 41 T-100 segment data.
10. Capacity improvement figures for TBFM and Reduced Diagonal Spacing are sourced from the FAA Airport Capacity Profile for SEA and FAA ASPM database analysis. TSAS is treated as a future improvement and is not included in baseline or projected capacity calculations.
11. Annual operations translation uses the standard FAA planning methodology as described in FAA Order 5090.3C (Field Formulation of the NPIAS).
12. Projection growth rates are derived from the FAA Terminal Area Forecast (TAF) 2024 edition, applied to a SEA-specific demand model maintained by the Port of Seattle Aviation Planning Division.
13. The constrained capacity ceiling is defined as the maximum sustained annual operations achievable without new runway construction, major apron expansion, or significant gate infrastructure additions.
14. All figures are rounded to the nearest 1,000 operations for annual projections and to the nearest whole number for hourly rates.

Section 10 – Assumptions

- Aircraft mix remains broadly consistent with the 2024 fleet (narrowbody-dominant: approximately 75% narrowbody, 20% widebody, 5% regional jet).
- No new runway construction occurs within the projection period (2024–2037).
- TSAS has not yet been deployed at SEA and is not assumed in any baseline or projected scenario; capacity projections reflect only currently operational improvements (TBFM and Reduced Diagonal Spacing).

- Weather distribution (VMC/IMC split) remains consistent with the 10-year historical average (approximately 70% VMC, 30% IMC).
- No extraordinary demand-deflating events — such as prolonged economic recession or public health emergencies — occur beyond modeled variability ranges.
- FAA staffing levels and ATC operational procedures remain at or above 2024 performance levels throughout the projection period.
- Gate utilization rates follow current Port of Seattle published gate assignment practices, with no assumed expansion of gate count in the constrained scenario.
- Growth rates from FAA TAF 2024 are treated as central-case estimates; sensitivity ranges are addressed separately in the main white paper body.

Section 11 – Data Sources

Table 11-1: Data Sources

Source	Description	Year	Use in Analysis
FAA Capacity Benchmark Report	Hourly declared capacity by airport and meteorological condition	2016	Baseline flow rates
FAA ASPM Database	Actual throughput, delay, and utilization metrics by airport and hour	2020–2026	Observed performance data
BTS Form 41 T-100	Airline segment operations and enplanement data by airport	2020–2026	Annual operations validation
FAA Terminal Area Forecast (TAF)	Airport-level demand projections by year and category	2024 edition	Unconstrained growth rates
FAA NextGen TSAS Evaluation	TSAS deployment performance assessments at SEA and system-wide	2019–2023	TSAS impact quantification

Source	Description	Year	Use in Analysis
FAA Order 5090.3C	NPIAS field formulation methodology and planning standards	Current	Annual operations translation method
Port of Seattle Internal Analysis	Gate utilization, apron counts, and constraint modeling	2024–2026	Constrained scenario inputs
FAA Capacity Needs NAS Study	National capacity framework and airport-level benchmarking	2016	Baseline context and SEA benchmarking

Section 12 – Definitions and Abbreviations

Table 12-1: Definitions and Abbreviations

Term	Definition
ASPM	Aviation System Performance Metrics — FAA database tracking throughput, delay, and efficiency metrics by airport and time period
BTS	Bureau of Transportation Statistics — federal agency publishing airline operations and enplanement data including Form 41 T-100 segment data
IMC	Instrument Meteorological Conditions — weather conditions requiring instrument approach procedures; generally ceiling below 1,000 feet and/or visibility below 3 miles
VMC	Visual Meteorological Conditions — weather conditions permitting visual approach and departure procedures, enabling higher throughput than IMC
ops/hr	Aircraft operations per hour — the combined count of arrivals and departures in a one-hour period unless stated separately
TAF	Terminal Area Forecast — FAA annual publication projecting airport-level operations and enplanements by year
TSAS	Terminal Sequencing and Spacing — FAA NextGen automation tool providing arrival sequencing optimization and speed/spacing advisories to air traffic controllers

Term	Definition
CAT II/III	Instrument approach categories for low-visibility operations; CAT II requires RVR 1,200 feet or greater; CAT III permits operations below CAT II minima with qualifying aircraft and ground equipment
NPIAS	National Plan of Integrated Airport Systems — FAA planning framework identifying airports of national significance and guiding federal airport investment
SEA	Seattle-Tacoma International Airport — IATA designator; operated by the Port of Seattle; primary commercial service airport for the Puget Sound region
FAA	Federal Aviation Administration — U.S. Department of Transportation agency responsible for the regulation and oversight of civil aviation
TBFM	Time-Based Flow Management — FAA en route metering system that sequences arriving aircraft based on scheduled arrival times, reducing miles-in-trail restrictions and improving runway delivery consistency
PBN	Performance-Based Navigation — ICAO framework for navigation specifications based on aircraft performance requirements, enabling more precise approach and departure procedures