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TECHNICAL MEMORANDUM No.5 FINAL

FACILITY REQUIREMENTS

Seattle-Tacoma International Airport

Prepared for

Port of Seattle
Seattle, Washington

June 2017

Sustainable Airport Master Plan
Seattle-Tacoma International Airport

LeighFisher

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Introduction and Summary

This chapter summarizes the requirements for major functional areas of the Airport through the 20-year planning period.

1.1 Background and Purpose

This *Technical Memorandum No. 5 – Facility Requirements* is the fifth in a series of memorandums which document the analyses, results, conclusions, and recommendations resulting from the Sustainable Airport Master Plan (SAMP) for Seattle-Tacoma International Airport. This Technical Memorandum summarizes the requirements for facilities and associated land areas to accommodate future aviation demand at the Airport, as presented in *Technical Memorandum No. 4 –Forecasts of Aviation Activity*. The facility requirements analyses and results have been organized according to the following functional areas:

- Airfield
- Passenger terminal
- Ground access and parking
- Air cargo
- Airline support
- Airport support
- General aviation

1.2 Planning Activity Levels

Recognizing the uncertainties associated with long-range aviation activity forecasting, four planning activity levels (PALs) were identified to represent future levels of activity at which key Airport improvements will be necessary. Because, for any number of reasons, activity levels could occur at different periods from those anticipated when the forecasts were prepared, the use of PALs allows for facilities planning that is realistically tied to milestone activity levels as they occur, rather than arbitrary years. PAL 1, PAL 2, PAL 3, and PAL 4, and correspond to the forecasts for 2019, 2024, 2029, and 2034, respectively. The aviation activity forecasts associated with each PAL are summarized in Table 1-1. The base year for the forecasts was 2014; even though this document was finalized in 2017, estimated values shown in Table 1-1 and subsequent tables are shown for the base year.

Table 1-1
Aviation Activity Forecasts
Seattle-Tacoma International Airport

	Estimated 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Total passengers (millions)	37.4	44.8	51.8	58.9	65.6
Aircraft operations	340,478	398,910	448,860	497,180	540,400
Total cargo (metric tons)	319,842	351,550	383,000	413,750	441,860

Source: LeighFisher, September 2015.

1.3 Summary of Requirements

The most significant conclusions from the requirements analyses were:

- Improvements in airfield facilities and airfield and airspace operating strategies will be needed beyond the PAL 3 (2029) planning period to avoid high aircraft delay,
- The number of gates available at the Airport is substantially below the number currently needed. By PAL 3 (2029) 24 additional gates will be required; by PAL 4 (2034) 35 additional gates will be required.
- Significant increases in terminal and landside capacity are needed. The application of newer technologies will yield significant capacity and productivity gains for certain passenger processing functions (e.g., ticketing). However, the existing passenger terminal and roadway system cannot accommodate forecast demand without major expansion and modification. Increased activity will exacerbate existing deficiencies in areas required for basic passenger terminal functions such as general passenger circulation, baggage make up, and baggage claim and basic landside functions such as curbsides and roadways.
- Significant increases in cargo warehouse capacity are needed.

Estimates of facility requirements are summarized in Table 1-2.

1.3.1 Airfield

This section summarizes our assessments of airfield capacity and airfield facility requirements.

1.3.1.1 Airfield Capacity

This section summarizes our assessment of the facilities, operations, and characteristics of the operations that most influence airfield capacity.

Airfield Geometry

Five characteristics of the Airport's airfield can limit airfield capacity:

- **Location of passenger terminal relative to runways**. The location of the terminal to one side of the airfield increases the number of times landing aircraft must taxi across an active runway.
- **Location of runway exits**. The location of certain runway exits may increase the time arriving aircraft remain on the runway, particularly on inboard Runway 16L-34R.
- **Effectiveness of taxiway system**. The *Airport's limited taxiway system causes many* interactions *between taxiing and* airborne aircraft. *which result in* dependencies between operations on the taxiway system and operations on the runway system.
- **Proximity of runways to terminal area**. Limited space between Runway 16L-34R and the passenger terminal may limit the taxiway system, limit taxiway capacity, and therefore limit airfield capacity (i.e., the taxiway system may not be able to accept aircraft as quickly as the runways can deliver them).
- ***Runway stagger**.* The southern thresholds of the Airport's three runways are offset from one another (i.e., they are "staggered"). During certain weather conditions, the air traffic control rules related to this stagger require greater separations between operations than would be case otherwise.

Airspace Interactions

Interactions between operations at the Airport and operations at Boeing Field also can limit airfield capacity.

Air Traffic Control and Airspace Constraints

Several factors related to air traffic control procedures and physical facilities at the Airport reduce airfield capacity.

- **Divergent departures headings.** Departing aircraft are no longer permitted to "fan out" on divergent headings.
- **Noise corridors.** A noise "corridor" exists to both the north and south of the Airport. All departing aircraft must use these corridors.
- **Runway spacing.** The spacing between the Airport's runways requires dependent approaches in poor weather.

Fleet Mix

The size of aircraft using the Airport has increased over the last 15 years. This trend towards larger aircraft has led to increases in required aircraft separation, resulting in decreased capacity.

Weather

Weather conditions—cloud ceiling and visibility—determine which air traffic control rules and procedures can be used at the Airport, which in turn affect airfield capacity. The rules governing operations during poor weather conditions (i.e., conditions of reduced cloud ceiling and visibility) are more restrictive than the rules governing operations during good weather conditions.

1.3.1.2 Airfield Facility Requirements

This section summarizes our assessment of facility requirements related to airfield capacity and compliance with FAA design criteria.

Airfield Facility Requirements Related to Airfield Capacity

The most significant conclusion from the airfield facility requirements analysis was that improvements in airfield facilities and airfield and airspace operating strategies will be needed beyond the PAL 3 (2029) planning period to avoid high aircraft delay.

Airfield Facility Requirements Related to FAA Design Criteria Compliance

It is not an unusual circumstance when some characteristics of airport airfield facilities do not comply with current FAA design criteria (i.e., standards). Similar to building codes, design criteria evolve over time. Non-compliance does not indicate unsafe conditions. We reviewed the current modifications to design standards and assessed the Airport's existing airfield layout, signage, and lighting for compliance with applicable FAA design criteria. As a result, we identified eight compliance issues for which facility improvements and/or further study are required:

- **Separation Between Runway 16L-34R and Taxiway B.** The separation required between the centerline of Runway 16L and the centerline of airplane design group V Taxiway B is 500 feet when airplanes in approach categories C, D, and E are conducting approaches with visibility minimums lower than ½ mile. The existing separation is 400 feet. **Existing Airfield Intersection Geometry.** We identified eight intersections involving Taxiway B that require fillet widening to meet the design standards for a B777-300 aircraft (the design aircraft).

- **Blast Pad Geometry.** The blast pads for Runway 16R-34L are currently too small and require enlarging.

- **Runway Incursion Mitigation and Hot Spot Locations**. Hot Spot (HS) locations are airfield geometry on an airport movement area with a history of potential risk of collision or runway incursion, and where heightened attention by pilots and drivers is necessary. HS-1 has been an area on the airfield where runway incursions have occurred in the past. According to the FAA, aircraft taxiing west on Taxiway Q to the end of Runway 34C via Taxiway Q sometimes enter the Runway 34R safety area without authorization Additional mitigation measures are needed at this location.

HS 2 is an area on the airfield where aircraft sometimes exit Runaway 34C on Taxiway F and proceed past hold position marking for Runway 16L-34R without authorization. The requirement is to identify the preferred alternative for resolving this issue.

- **High-Energy Intersections.** The "high energy" portion of a runway is the middle third, where a pilot can least maneuver to avoid a collision. High energy runway-taxiway intersections are intersections that occur in the high-energy portion of a runway. Runway 16C-34C and Runway 16L-34R each has at least one high-energy runway-taxiway crossing. The requirement is to identify a preferred solution that can be implemented at the appropriate time.

- **Right-angle Intersections**. Right angle intersections provide pilots of taxiing aircraft with increased visibility between taxiways and between taxiways and runways. Acute-angle taxiways should not be used as runway entrance or crossing points. Six such acute-angle taxiway crossings of Runway 16C-34C were identified. These should be replaced with right-angle crossings when taxiway rehabilitation is necessary.

- **Direct Access to Runway From an Apron.** FAA design guidance states "do not design taxiways to lead directly from an apron to a runway without requiring a turn." We identified two such conditions, one at Taxiway L and one at Taxiway N, where direct access from the apron to Runway 16L-34 is provided. A preferred solution that can be implemented at the appropriate time is required.

- **Three-Node Concept**. The three-node concept is based on reducing complex intersections by limiting a pilot to no more than three choices when entering an intersection. An intersection not adhering to the three-node concept occurs on Taxiway A at its intersection with Taxiways C and D near the Runway 16L threshold. A preferred solution for reconfiguring this intersection as soon as possible is required.

- **High-Speed Exit Placement.** The center two high speed exits from Runway 16C-34C, K and M, are poorly located. A preferred solution for reconfiguring these exits is required.

- **No-Taxi Islands**. To reduce the possibility of runway incursions, all designs for a direct entrance to a runway that use two or more taxiway entrances must separate the entrances with "NO-TAXI islands". A preferred solution for installing a NO-TAXI island between the Runway 34R threshold and its adjacent entrance and bypass

1.3.2 Passenger Terminal

This section summarizes our assessments of passenger terminal operations and facility requirements.

1.3.2.1 Existing Facilities and Operations

The conclusions from our assessment of the passenger terminal operations are summarized below.

Arrivals level

- The arrivals level facilities do not provide the desired level of service to passengers and the public. This issue will be exacerbated as activity increases.
- The ramps leading to the lower level curbside reduce the amount of usable space on the arrivals level by forcing passenger circulation into the bag claim area. This limits the overall efficiency of the space, limits opportunities to expand, and degrades the level of service provided.
- Escalator cores encroach on the space and provide visual barriers between the bag claim areas.
- The capacity of the baggage claim devices (i.e., the length of the belts, also referred to as presentation length) and the surrounding claim areas is insufficient, resulting in crowding and below standard levels of service.

Ticketing level

- The ticketing level does not consistently provide the desired level of customer service.
- The ability to expand the security screening checkpoints is currently limited by existing functions. Security screening checkpoint queues currently encroach on passenger circulation areas behind the ticket counters to the extent that they severely restrict access to the checkpoints, food, beverages, and concessions.
- Ticketing functions are spread out and arrayed in multiple configurations and not as efficient as possible.
- Ramps from the upper level roadway and escalators from the mezzanine level below encroach on the ticketing level space and force passenger circulation further into the building. This results in underutilized space, the misalignment of passenger functions with passenger flows, and severely restricted passenger circulation paths.

Concourse A

- The existing holdrooms are adequate and could be expanded if necessary.
- The distribution, density and quality of concessions should increase with the addition of international arrival and departure gates.
- The travel distance to and the size of existing toilet facilities appears to be adequate. As the size of aircraft during the peak hour increases there may be times when toilet facilities will become crowded.

Concourse B

- Existing holdrooms are undersized for the existing aircraft mix and passengers often stand in the circulation corridor.

- The concessions on Concourse B are limited in size and locations. Sizes are constrained due to the size of the concourse and locations are limited because of holdroom needs.

- The distance to toilet facilities is acceptable but the number of fixtures available is insufficient.

Concourse C

- The holdroom space appears adequate for the current aircraft accommodated.

- The food and beverage and retail facilities in Concourse C appear to be adequate.

- The locations and sizes of toilets appear to be adequate

Concourse D

- The width of Concourse D is narrow and limits passenger movement.

- The existing holdrooms vary in size. The holdrooms at gates D1-D6 may experience some crowding but do not need to be enlarged. The holdrooms at Gates D6-D10 are spacious and permit holdroom sharing to avoid crowding at a single gate.

- There are few concessions available in Concourse D and their opportunity to expand is limited by the existing space.

- The number and locations of toilets appear adequate for the gates being served

South Satellite

- The holdrooms are currently adequate for the aircraft accommodated. As the number of widebody aircraft accommodated increases, the holdrooms will need to be modified accordingly.

- All concessions are currently located in a central food court and restaurant with some retail at the edges. The concessions space will be modified during the renovation project.

- Existing toilets meet the needs of the gates being served. Adjustments may be appropriate during the planned renovation project.

Satellite Transit System

- While the existing system adequately serves the current concourses, the addition of a significant number of new gates may result in the requirement for system modifications to maintain the current passenger minimum connect time between international and domestic flights (currently 80 minutes).

- The existing system can continue to be utilized to serve all or a part of the existing concourses but another system or extension of the existing STS may ultimately be needed for new gates.

U.S. Customs and Border Protection Facilities

- The U.S. Customs and Border Protection facilities at the Airport, located in the South Satellite and constructed in 1973, have reached capacity. The Port Commission has directed that a new International Arrivals Facility, housing new Customs and Border Protection facilities, will be constructed as quickly as possible.

- In parallel with the SAMP, IAF programming and planning were completed in August 2014. Design of the new International Arrivals Facility is underway.

1.3.2.2 Passenger Terminal Facilities Requirements

This section summarizes the requirements for those terminal functions that will most influence the development of terminal alternatives.

Gates

The number of gates available at the Airport is substantially below the number currently needed. By PAL 3 (2029) 24 additional gates will be required; by PAL 4 (2034) 35 additional gates will be required.

Passenger Processing Facilities

Significant increases in passenger processing capacity are needed. The application of newer technologies will yield significant capacity and productivity gains for certain passenger processing functions (e.g., ticketing). However, the existing passenger terminal cannot accommodate forecast demand without major expansion and modification. Increased activity will exacerbate existing deficiencies in areas required for basic passenger processing functions such as general passenger circulation, baggage make up, and baggage claim.

Baggage Handling Systems

Baggage handling systems (BHS) are complex, expensive, and require considerable space. Given the technical complexities of BHS, the Port has engaged a BHS designer who is responsible for the concepts and systems related to baggage screening, early baggage storage, and a baggage conveyor "backbone" are being planned; collectively, these systems will be incorporated into a project referred to as the Baggage Optimization Project. The planning team has coordinated with the BHS designer. However, final decisions governing the overall BHS design have not been made and will occur during detailed planning and design that will occur following completion of the SAMP. Given the responsibilities of the BHS designer, SAMP BHS planning focused on requirements for outbound makeup areas, inbound claim devices, and domestic baggage claim.

Automated People Mover System

The distance between the new IAF located at Concourse A and new domestic gates (locations to be determined during the alternatives task) may create challenges for passengers connecting from arriving international flights to departing domestic flights. In order to deliver these passengers with a high level of service, the chosen system(s) should be able to provide a minimum connect time of 80 minutes. This high level of connecting service should be achievable across all gates, regardless of their locations. The automated people mover system also should provide high levels of service for passengers connecting between domestic flights. The objective is to effectively integrate the existing satellite transit system and automated people mover system, if any, to simplify the inter-Airport transportation experience.

U.S. Customs and Border Protection Facilities

The new International Arrivals Facility is being designed to (1) increase passenger processing capacity by more than double to 2,600 passengers per hour, (2) nearly double the number of gates capable of serving international wide-body aircraft (from 12 to 20), (3) more than double Passport Check booths and kiosks (from 30 to 80 booths), (4) increase the size and number of bag claim carousels from four to seven, (5) create a single bag claim process, eliminating the need for international passengers to ride a train to baggage claim, and (6) create direct access to ground transportation.

1.3.3 Ground Access and Parking

This section summarizes our assessments of ground access and parking operations and facility requirements.

1.3.3.1 Existing Facilities and Operations

The conclusions from our assessment of the ground access and parking operations are summarized below.

Off-Airport Roadways

- Off-Airport roads of particular importance for the Airport include the surrounding state and regional highway network (i.e., I-5, I-405, SR 518, and SR 509) as well as local roadways (i.e., SR 99 / International Boulevard, S. 188th St, S. 170th St, and S. 160th St) that provide access to and from the Airport. Although the Port does not control these off-Airport access roadways, and their future requirements are outside the scope of the SAMP, the roads were evaluated by Port staff.

- Between the Airport and I-5, the Airport contributes a significant share of the total traffic during the peak hour. On I-5, SR 509, and International Blvd., however, the Airport contributes a very small share of the total volume. A high share of Airport traffic (87%) enters the Airport from the north via the North Airport Expressway while the remainder (13%) enters from the south via City of SeaTac streets. However, approximately 74% of Airport traffic is generated from areas north of the Airport. This discrepancy reflects that a high share of traffic generated to the south uses I-5 and SR 518 to travel to the Airport and therefore, enters Airport property from the north.

- According to Port staff, even though eastbound SR 518 has available capacity in the afternoon, congestion at the I-5/I-405 interchange causes traffic to back up along SR 518. Other conclusions are that congestion from on-Airport roadways occasionally reaches the SR 518 corridor, creating turbulence on westbound SR 518.

On-Airport Access Roadways

Key access roadways, such as the southbound North Airport Expressway, currently experience congestion due to deficiencies on terminal-area roadways, which cause traffic to back up onto access roadways.

Terminal-Area Circulation Roadways

Two of four key terminal-area roadway segments, the approach to the Lower Drive (which, in addition to curbside traffic, includes all traffic entering the 3rd floor courtesy vehicle lanes and approaching the Main Garage from the north) and the exit from the Upper Drive, currently operate at level-of-service E. Level of service E is the next to lowest level of service defined in the Transportation Research Board's *Highway Capacity Manual*. These conditions result in traffic backing up into upstream facilities, such as the Upper Drive and North Airport Expressway.

Curbside Roadways

Curbside requirements are based on vehicle volumes, dwell times, vehicle lengths, and the assumption that demand is uniformly distributed along the curbside length. In practice, dwell times have traditionally been longer and curbside demand has been concentrated in front of major air carriers (i.e., Alaska Airlines). However, dwell times and distribution along the curb can be addressed in whole or in part through increased curbside enforcement and other operational strategies intended to improve the distribution of demand along the curbside.

Cruise Ship Facilities

In 2017 the cruise ship operation in the North Charter Bus Lot will be permanently displaced by the construction of a holdroom for passengers bused to remote gates. Similarly, cruise ship operations at the South Ground Transportation Lot will be permanently displaced due to construction of the IAF. Short-term alternatives for replacing the lost facilities and operations have been developed by Airport Operations; however, a long a long-term solution is needed.

1.3.3.2 Ground Access and Parking Requirements

Off-Airport Roadways

The future effectiveness of off-Airport roadways is essential to efficient Airport access. However, the Port does not control off-Airport roadways and is not responsible for identifying and satisfying their requirements. Port staff should closely coordinate the Airport's future needs with the regional and national agencies responsible for off-Airport roadways.

Terminal-Area Circulation and Curbside Roadways

Significant increases in on-Airport terminal-area circulation roadway and curbside roadway capacity are needed. The existing roadway system cannot accommodate the forecast demand without major expansion and modification. Increased activity will exacerbate existing deficiencies in areas required for basic landside functions such as roadways and curbsides.

Public Parking

The Main Garage and Doug Fox Lot have sufficient capacity to continue to meet parking demand through PAL 4 (2034). Off-Airport parking facilities, however, will need either to increase capacity or reduce their share of the market.

Rental Car Facilities

By PAL 4 (2034), rental car facilities will need to grow by approximately 15%.

Cruise Ship Facilities

Mid- and long-term solutions for cruise ship facilities at the airport will be developed during advanced planning following completion of the SAMP. The term "advanced planning" is used frequently in this document and broadly refers to planning activities that involve greater detail and specificity than are appropriate during master planning.

1.3.4 Air Cargo

This section summarizes our assessments of air cargo operations and facility requirements.

1.3.4.1 Existing Facilities and Operations

- With the exception of FedEx, warehouses at the Airport do not employ a high level of mechanization or sophisticated cargo storage & handling systems. Instead their operations rely on simple forklifts, dollies, and tugs; at most warehouses, cargo is stored directly on the floor for processing and storage during its short dwell time.

- Current issues at cargo facilities are more attributable to layout-related congestion than to actual capacity deficits. This congestion is exacerbated by activity generated by non-cargo operations, such as the Port's aviation maintenance facility, flight kitchen, and United Airlines maintenance operations interspersed within the cargo campus.

- The nature of the commercial relationships between the Airport and its cargo tenants constrains the Airport's ability to impose a strict cargo-oriented policy. Tenants are free to sub-lease Airport property originally designated for cargo to non-cargo users, and the Airport has little ability to control such behavior. Additionally, in contrast with business arrangements at other international airports, Airport staff is not involved in determining or mandating service levels and standards. The result is an assortment of relatively small warehouses, each operating individually as best suits its own interests, and the less than optimum utilization of the relatively large area currently allocated to cargo operations.

1.3.4.2 Air Cargo Requirements

- Air cargo facility requirements were estimated for both the volume of air cargo specified by the Century Agenda as well as the volume of air cargo forecast for PALs 1 through 4. The Century agenda air cargo volume exceeds the forecast air cargo activity by approximately 50%.

- A significant increase in air cargo warehouse capacity is needed. By PAL 4 (2034) we estimate that total cargo warehouse area must increase:
- Approximately 43% over the current warehouse area utilized for air cargo—assuming the forecast air cargo activity.
- Approximately 112% over the current warehouse area utilized for air cargo—assuming the forecast air cargo activity.

A significant increase in freighter aircraft hardstand capacity is needed. By PAL 4 (2034) we estimate that the total number of freighter hard positions must increase by approximately 36%.

1.3.5 Airline Support

Airline support facilities include aircraft maintenance hangars, flight kitchens, ground handling service facilities, fuel storage and distribution facilities, and office space.

Alaska Airlines has two aircraft maintenance hangars located to the south of the South Satellite. Delta Air Lines has a single aircraft maintenance hangar located adjacent and to the east of the Alaska hangars. Neither Alaska Airlines nor Delta Air Lines has stated the requirement for additional aircraft maintenance hangars during the planning period.

The airlines and their service providers are responsible for determining the requirements for the flight kitchens. Locating the flight kitchens on Airport property is a convenience but not a necessity.

The future requirements for ground handling services facilities at the Airport will increase as the volume of passenger and aircraft activity increases. The requirements for such facilities will be determined during the advanced planning after the SAMP is completed.

Jet fuel is delivered to the Airport from multiple refineries in Northern Washington via the Olympic Pipeline. The need for a backup delivery source would involve off-Airport facilities and should be explored in advanced planning. The requirement for the future jet-fuel tank storage capacity depends on how many days of reserve jet-fuel the airlines desire for their operations. For the purposes of the SAMP, we have estimated requirements for a range of reserves (3-, 5-, 7-, and 10-days reserve supply).

As part of the SAMP, the airlines have not stated requirements for additional office space. Nevertheless, it is anticipated that such requirements at the Airport will change as the volume of passenger and aircraft activity increases. We assumed (a) the amount of space available for airline offices will increase in the future as additional passenger terminal and gate facilities are provided, (b) specific needs for office space will be determined following completion of the SAMP, and (c) the Port will continue to reallocate existing office space to meet changing future needs.

1.3.6 Airport Support

Airport support facilities include those related to aviation maintenance, aircraft rescue and firefighting, aircraft ground run-up, concessions distribution, recycling and composting, and utilities.

We anticipate the need to relocate many aviation maintenance facilities and have estimated the appropriate requirements. The most significant—and current—need is to relocate the existing maintenance complex located at cargo 4.

We anticipate that the expansion of the Airport's passenger terminal facilities will require that the existing fire station be demolished and replaced with one or more new facilities. We estimated the requirements accordingly.

A ground run-up enclosure is a three-sided structure used to minimize aircraft noise generated when maintenance personnel test aircraft engines. There is no GRE at the Airport. We estimated the area required to accommodate such a facility.

The Airport's existing utility infrastructure systems (i.e., electrical, mechanical, sanitary sewer, storm water drainage, and industrial waste) and the supporting regional infrastructure (e.g., power, water, and sewerage) are generally adequate to meet current and future needs. The utilities requirements associated with future projects will be determined by the specifics of each project and will be determined either during advanced planning or design.

1.3.7 General Aviation

The site utilized to accommodate itinerant general aviation aircraft (i.e., the site accommodating both the fixed base operator building and itinerant aircraft apron) be retained for use by general aviation; it is adequate to accommodate demand through PAL 4 (2034); no increase in size is recommended. There is no requirement to continue leasing land to the Weyerhaeuser Corporation for its corporate hangar.

Table 1-2
Facility Requirements Summary
Seattle-Tacoma International Airport

Facility	Existing (2014)	PAL 1 (2019)	PAL 2 (2024)	PAL 3 (2029)	PAL 4 (2034)	Sources
BASIS FOR FACILITY REQUIREMENTS (UNCONSTRAINED FORECASTS OF AVIATION ACTIVITY)						
Total annual passengers (millions)	37.4	44.8	51.8	58.9	65.6	LeighFisher, 2015
Air Cargo (metric tons)						
SAMP forecast						LeighFisher, 2015
Air freight	163,233	188,370	211,770	234,090	253,400	
Integrator freight	105,505	110,590	116,990	123,750	130,900	
Air mail	50,752	52,520	54,160	55,820	57,470	
Total	319,490	351,480	382,920	413,660	441,770	
Century Agenda goal						Port Commission, 2012
Air freight	164,444	201,895	247,784	304,325	373,631	
Integrator freight	104,535	128,342	157,571	193,456	237,513	
Air mail	50,863	52,520	54,160	55,820	57,470	
Total	319,842	382,757	459,515	553,601	668,614	
Aircraft operations	340,478	398,910	448,860	497,180	540,400	LeighFisher, 2015
AIRFIELD						
Number of runways	3	3	3	3	3	LeighFisher, 2015
Design aircraft						LeighFisher, 2015
Aircraft Approach Category *(a)*	D	D	D	D	D	
Airplane Design Group *(b)*	V	V	V	V	V	
Taxiway Design Group *(c)*	6	6	6	6	6	
Runway length (feet)						LeighFisher, 2015
Runway 16L - 34R	11,901	Existing length is adequate				
Runway 16C - 34C	9,426	Existing length is adequate				
Runway 16R - 34L	8,500	Existing length is adequate				
Instrument approach capability	CAT III	CAT III	CAT III	CAT III	CAT III	LeighFisher, 2015
Capacity-related requirements						
Identify physical and procedural improvements to enhance efficiency, increase capacity, and reduce delay		X	X	X	X	LeighFisher, 2015
Provide de-ice pads near thresholds of Runway 16L-34R				X	X	Port of Seattle, 2014
Compliance-related requirements						
Separation between Runway 16R-34L and Taxiway B	No expansion, beyond that already approved, to impede meeting 500 foot standard.					FAA, 2017
Widen fillets at intersections of Taxiway B with Runway 34R and Taxiways D, E, H, K, M, N, and Q			X			CH2M Hill, 2017
Enlarge blast pads for Runway 16R-34L			X			CH2M Hill, 2017
Additional mitigation for Runway Incursion Mitigation locations HS 1 & HS 2		X				CH2M Hill, 2017
Eliminate taxiway-runway crossings in high-energy portion of:						CH2M Hill, 2017
Runway 16C-34C ; Taxiway J				X		
Runway 16L-34R; Taxiways K, M, N				X		
Eliminate acute-angled intersections between Runway 16L-34R and crossing taxiways F, H, K, M, N, and P				X	X	CH2M Hill, 2017
Modify taxiways providing direct access to runway from apron (Taxiways L and N)		X	X			CH2M Hill, 2017
Install "3-node" concept on Taxiway A near Runway 16L threshold		X				CH2M Hill, 2017

Table 1-2 *(continued)*
Facility Requirements Summary
Seattle-Tacoma International Airport

Facility	Existing (2014)	PAL 1 (2019)	PAL 2 (2024)	PAL 3 (2029)	PAL 4 (2034)	Sources
PASSENGER TERMINAL						LeighFisher, 2015
Aircraft gates						
Domestic gates *(d)*						
RJ/TP	20	19	21	21	12	
Jet III	32	47	50	51	63	
Jet IV	12	10	10	8	6	
Jet V	6	1	1	2	3	
Jet VI	--	--	--	--	--	
Total	70	77	82	82	84	
International gates *(d)*						
RJ/TP	1	0	0	0	0	
Jet III	0	0	1	0	2	
Jet IV	2	2	2	2	0	
Jet V	8	16	19	22	27	
Jet VI	2	--	--	--	--	
Total	13	18	22	24	29	
Total gates *(d)*						
RJ/TP	21	19	21	21	12	
Jet III	32	47	51	51	65	
Jet IV	14	12	12	10	6	
Jet V	14	17	20	24	30	
Jet VI	2	--	--	--	--	
Total	83	95	104	106	113	
Off-gate parking positions *(e)*						Port of Seattle, 2014
RJ/TP		1	2	3	4	
Jet III		20	22	27	30	
Jet IV		3	4	3	3	
Jet V		4	3	4	7	
Jet VI		--	--	--	--	
Total		28	31	37	44	
Passenger check-in facilities						LeighFisher, 2015
Check-in lobby						
Kiosk no bag check	40	77	80	84	90	
Agent with bag check	214	211	219	235	250	
Garage	15	11	11	11	12	
Curb	15	14	15	16	17	
Passenger security screening checkpoints						LeighFisher, 2015
Number of screening lanes	31	34	36	37	41	
Queue length with 10 min wait (pax)	n/a	992	1,050	1,079	1,196	
Domestic baggage claim						Logplan, 2016
Total claim frontage (feet)	2,700	2,982	3,441	4,136	4,453	
Number of claim devices	16	18	20	22	24	
Domestic and international outbound baggage						Logplan, 2016
Peak hour bags	3,564	4,748	5,911	7,444	8,135	
Security screening machines	12	9	11	15	16	
Make-up positions *(f)*	n/a	490	386	422	464	
Early-bag storage positions	0	n/a	393	652	715	
International Arrivals Facility						Port of Seattle, 2014
Processing capacity (pax per hour)	1,200	1,900	1,900	2,600	2,600	

Table 1-2 *(continued)*
Facility Requirements Summary
Seattle-Tacoma International Airport

Facility	Existing (2014)	PAL 1 (2019)	PAL 2 (2024)	PAL 3 (2029)	PAL 4 (2034)	Sources
ACCESS AND PARKING						
On-Airport access roadways (lanes)						InterVISTAS, 2016
Ramp from SR 518, westbound	2	2	3	3	3	
Ramp from SR 518, eastbound	1	1	1	2	2	
North Airport Expressway, southbound, prior to return-to-terminal ramp	3	3	4	4	5	
North Airport Expressway, southbound, after return-to-terminal ramp	3	4	4	5	5	
Terminal area entrance	4	4	5	6	6	
Terminal area exit to north	4	4	4	4	5	
North Airport Expressway, northbound, prior to return-to-terminal ramp	5	5	5	5	5	
North Airport Expressway, northbound, after return-to-terminal ramp	3	3	3	4	4	
Ramp to SR 518, eastbound	2	2	3	3	3	
Ramp to SR 518, westbound	2	2	2	2	2	
Return-to-terminal ramp	2	2	2	2	2	
On-ramp from Air Cargo Road	2	2	2	2	2	
Northbound exit to South 170th Street	1	1	1	1	1	
Southbound exit to South 170th Street	1	1	1	1	1	
Air Cargo Road, southbound, north of South 160th Street	2	2	2	2	2	
Air Cargo Road, northbound, north of South 160th Street	2	2	2	2	2	
Air Cargo Road, southbound, north of South 170th Street	1	1	1	1	1	
Air Cargo Road, northbound, north of South 170th Street	1	1	1	1	1	
Air Cargo Road, southbound, south of South 170th Street	1	1	1	1	1	
Air Cargo Road, northbound, south of South 170th Street	1	1	1	1	1	
Interim South Access, northbound	1	1	1	1	-	
Interim Access, southbound	1	2	2	2	-	
South Airport Expressway, northbound	--	--	--	--	2	
South Airport Expressway, southbound	--	--	--	--	2	
Terminal-area circulation roadways (lanes)						InterVISTAS, 2016
Approach to Upper Drive	2	2	2	3	3	
Approach to Lower Drive	2	4	4	5	5	
Upper Drive exit	1	2	2	2	2	
Lower Drive exit to northbound	2	2	2	3	3	
Curbside roadways (linear feet)						InterVISTAS, 2016
Enplaning curbside (upper drive)	1,200	1,180	1,260	1,320	1,460	
Deplaning curbside (lower drive)						
Public curb	1,050	1,250	1,350	1,390	1,480	
Rental car shuttles	360	600	720	780	900	
Public transit	120	120	120	120	120	
Total	1,530	1,970	2,190	2,290	2,500	
Curbside roadways (number of lanes)						InterVISTAS, 2016
Enplaning curbside (upper drive)	4	4	4	4	5	
Deplaning curbside (lower drive)	5	5	5	6	6	
Commercial vehicle loading areas (spaces)						InterVISTAS, 2016
Taxicabs	13	11	11	12	13	
Taxicab feeder queue	70	64	68	73	82	
On-call limousines	2	2	2	2	2	
Pre-arranged limousines	48	10	11	11	12	
Shared-ride vans	8	4	4	4	4	
Courtesy vehicles	22 *(g)*	22	22	22	24	
Airline crew vans		2	3	3	3	
Downtown shuttle		1	1	1	1	
Airporters	2	2	2	3	3	
Charter buses	20	19	21	21	23	

Table 1-2 *(continued)*
Facility Requirements Summary
Seattle-Tacoma International Airport

Facility	Existing (2014)	PAL 1 (2019)	PAL 2 (2024)	PAL 3 (2029)	PAL 4 (2034)	Sources
Public parking (spaces)						InterVISTAS, 2016
Close-in	12,800	9,260	10,440	11,590	12,740	
Remote	1,620	1,090	1,230	1,360	1,500	
Off-Airport	18,500	20,400	23,000	25.500	28,000	
Total public parking spaces	32,920	30,750	34.670	38,450	42,240	
Employee parking						Port of Seattle, 2016
Terminal Employees	4,810	4,900	5,500	6,200	6,900	
Cargo & Maintenance Employees						
Air Cargo Buildings (sf)	550,000	501,000	876,000	1,320,700	1,275,000	
Aircraft Maintenance Buildings (sf)	346,000	346,000	346,000	324,000	324,000	
Remote Employee Parking Stalls (spaces)	66	70	70	590	750	
On-Site Employee Parking Stalls (spaces)	1,271	1,280	1,810	1,720	1,490	
Total Employee Parking Stalls – Port Facilities	4,876	4,970	5,570	6,790	7.650	
Rental car facilities (thousand sf)	1,700	1,700	1,700	1,700	1,970	InterVISTAS, 2016
Cruise ship facilities	Solutions to be determined in advanced planning					Port of Seattle, 2017
Non-motorized access	Solutions to be determined in advanced planning					Port of Seattle, 2017
Commercial vehicle hold lot (spaces)						InterVISTAS, 2016
Taxicabs	98	--	--	--	190	
Transportation Network Companies	43	--	--	--	80	
Scheduled airporters	9	--	--	--	14	
Charter buses	18	--	--	--	30	
AIR CARGO						
Warehouse to meet forecast activity (sf)						Logplan, 2015
Air freight	n/a	270,000	303,000	335,000	362,000	
Integrator freight	n/a	74,000	78,000	83,000	87,000	
Air mail	n/a	53,000	54,000	56,000	57,000	
Total	n/a	397,000	435,000	474,000	506,000	
Warehouse to meet Century Agenda activity (sf)						Logplan, 2015
Air freight	n/a	288,000	354,000	435,000	534,000	
Integrator freight	n/a	86,000	105,000	129,000	158,000	
Air mail	n/a	53,000	54,000	56,000	57,000	
Total	n/a	427,000	513,000	620,000	749,000	
Freighter hardstands						LeighFisher, 2015
International freighters	4	5	5	6	6	
Diverted flights and maintenance	2	2	3	3	3	
Integrator freighters	6	6	7	8	8	
Domestic freighters	2	2	2	2	2	
Total	14	15	17	19	19	
AIRLINE SUPPORT						
Maintenance hangars	3	3	3	3	3	Alaska Airlines and Delta Air Lines, 2016
Flight kitchens	3	3	3	3	3	Port of Seattle, 2016
Fuel storage						
Based on 7-day reserves						Corich Group, 2016
Quantity (millions of gallons)	17	18	20	23	25	
Land area (acres)	11	11	12	14	15	
Based on 10-day reserves						Corich Group, 2016
Quantity (millions of gallons)	17	26	29	32	35	
Land area (acres)	11	16	18	20	21	

Table 1-2 *(continued)*
Facility Requirements Summary
Seattle-Tacoma International Airport

Facility	Existing (2014)	PAL 1 (2019)	PAL 2 (2024)	PAL 3 (2029)	PAL 4 (2034)	Sources
AIRPORT SUPPORT						
Aviation maintenance (acres)	5	6	6	6	6	Corich Group, 2016
Airport rescue and fire fighting (acres)						
East station	4	2	2	2	2	
West station	n/a	2	2	2	2	
Ground run up enclosure (acres)	n/a	2	2	2	2	Port of Seattle, 2016
Centralized receiving warehouse	n/a	To be determined during advanced planning				Port of Seattle, 2017
Centralized trash, recycling, and compost facility	n/a	To be determined during advanced planning				Port of Seattle, 2017
Utilities	n/a	To be determined during advanced planning				
GENERAL AVIATION	n/a	Preserve itinerant apron and FBO building				Port of Seattle, 2016

(a) Aircraft approach category D includes aircraft with an approach speed of 141 nautical miles per hour but less than 166 nautical miles per hour.

(b) Airplane design group V includes aircraft with a wingspan of 171 feet but less than 214 feet or tail height of 60 feet but less than 66 feet.

(c) Taxiway design groups are based on main gear width and cockpit to main gear distance and are defined in Federal Aviation Administration (FAA) Advisory Circular 150/5300-13A, Airport Design.

(d) Aircraft gates were classified according to wingspans included in airplane design groups (ADG) defined in FAA Advisory Circular 150/5300-13A, Airport Design.
- RJ/TP refers to regional jets or turboprops in either ADG I or ADG II and with wingspans no greater than 79 feet.
- Jet III refers to aircraft in ADG III which have wingspans greater than or equal to 79 feet but less than 118 feet.
- Jet IV refers to aircraft in ADG IV which have wingspans greater than or equal to 118 feet but less than 171 feet.
- Jet V refers to aircraft in ADG V which have wingspans greater than or equal to 171 feet but less than 214 feet.
- Jet VI refers to aircraft in ADG VI which have wingspans greater than or equal to 214 feet but less than 262 feet.

(e) "Off-gate" parking refers to the number of parking positions needed to accommodate remain-overnight (RON) aircraft. The requirements shown assume that all contact gates are fully utilized for RON aircraft.

(f) Bag make up requirements for PAL 1 and PAL 2 assume the installation of an early bag store system as recommended in the baggage optimization study.

(g) 22 spaces are shared among courtesy vehicles, airline crew vans, and the downtown shuttle.

Airfield

This chapter describes the requirements for developing the Airport's airfield facilities to accommodate activity forecast through PAL 4 (2034)

2.1 Introduction

Our assessment of the airfield focused primarily on identifying the requirements for physical improvements related to airfield capacity and delay and compliance with FAA design criteria.

The airfield, shown on Figure 2-1, consists of three runways and associated taxiways. Runway data, including key airfield dimensions and navigational aids, are summarized in Table 2-1. Taxiway characteristics are summarized in Table 2-2.

2.2 Existing Facilities and Operations

The airfield, shown on Figure 2-1, consists of three runways and associated taxiways. Runway data, including key airfield dimensions and navigational aids, are summarized in Table 2-1. Taxiway characteristics are summarized in Table 2-2.

This section describes our assessment of the facilities, operations, and characteristics of the operations that most influence airfield capacity. Discussions related to runway use and weather conditions have been intentionally omitted; these are provided in Technical Memorandum No. 6 Alternatives.

2.2.1 Airfield Geometry

The Airport's key physical geometric characteristics that can limit airfield capacity are described below.

- **Location of passenger terminal relative to runways.** The location of the terminal to one side of the airfield increases the number of times landing aircraft must taxi across an active runway. Such runway crossings affect runway and taxiway capacity.
- **Location of runway exits.** The location of certain runway exits may increase the time an arriving aircraft remains on the runway, particularly on inboard Runway 16L-34R. This additional runway occupancy time adversely affects runway capacity.
- **Effectiveness of taxiway system.** The extent to which taxiing aircraft can move between the runways and gates in a manner that minimizes interactions with airborne aircraft. can reduce dependencies between operations on the taxiway system and operations on the runway system.
- **Proximity of runways to terminal area.** Limited space between Runway 16L-34R and the passenger terminal may limit the taxiway system, limit taxiway capacity, and

therefore limit airfield capacity (i.e., the taxiway system may not be able to accept aircraft as quickly as the runways can deliver them).

- **Runway stagger (i.e., extent to which adjacent runway thresholds are offset from one another).** Simultaneous arrivals to one runway and departures from a parallel runway in Instrument Meteorological Conditions (IMC) require at least 2,500-foot spacing between runway centerlines and no adverse stagger (i.e., a stagger where the far runway threshold is used for arrivals). The general rule for airports where the ends of two parallel runways are offset from one another (i.e., "staggered") is that the assumed centerline-to-centerline separation of the runways must be adjusted because that required spacing also depends on the magnitude and direction of the stagger. Staggered runways fall into two categories: (1) favorable stagger and (2) adverse stagger. The adjustment in the required no-stagger separation of 2,500 feet is 100 feet for every 500 feet of stagger (favorable or adverse). For example, the adverse stagger at the Airport is about 3,300 feet. Therefore, according to this rule, the runway centerlines of Runways 34L and 34R would need to be separated by 2,500 feet plus 100*(3,300/500), or about 3,160 feet for independent arrival and departure operations on Runways 34L and 34R, respectively.

2.2.2 Airspace Interactions

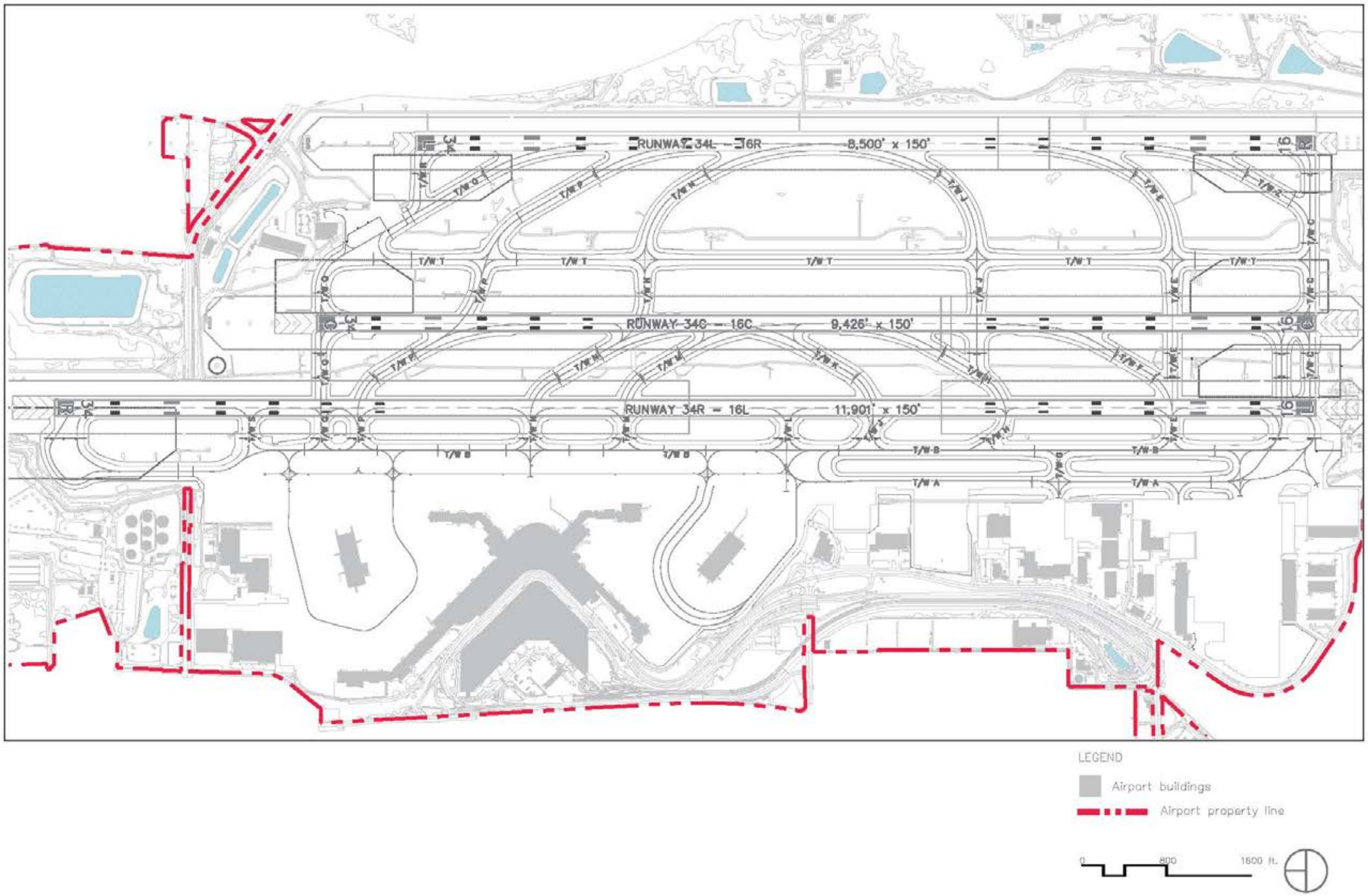
Three interactions that occur between the Airport and Boeing Field (BFI) and reduce the Airport's airfield capacity are described below.

- **South Flow Instrument Meteorological Conditions (IMC).** There is an interaction between aircraft arriving into the Airport from the north (i.e., south flow) and BFI, that requires protection for missed approaches into BFI – known as Plan Alpha. This situation occurs when cloud ceilings are less than 2,500 feet, and air traffic controllers at BFI cannot see arriving aircraft into the Airport. Weather conditions which cause this interaction occur approximately 14.9% of the time (4.8% of the time during peak operating time of 7 am-9 pm).

- **North Flow IMC.** There is an interaction between aircraft departing from the Airport to the north (i.e., north flow) and arrivals to BFI. Departures from the Airport are assigned an initial heading of 20 degrees, also known as Plan Charlie, and are held on the ground from the time when a BFI arrival is at the final approach fix until landing is assured (one-in, one-out), resulting in a loss of capacity at the Airport. North flow IMC occurs approximately 0.8% of the time.

- **South Flow Visual Meteorological Conditions (VMC).** There is an interaction between arrivals into the Airport and BFI. Typically, a common arrival stream into the Airport stays above arrival stream into BFI. However, if dual approaches to Runway 16R and 16L into the Airport are being conducted, dual arrival streams are used, and additional spacing is required so that aircraft can keep each other in sight.

Figure 2-1
Airfield Layout
Seattle-Tacoma International Airport



Source: Port "Airport Facilities" drawing (June 2014), updated June 2017.

Table 2-1
Runway Data
Seattle-Tacoma International Airport

	Runway					
	16L	34R	16C	34C	16R	34L
Runway length (feet)	11,901	11,901	9,426	9,426	8,500	8,500
Runway width (feet)	150	150	150	150	150	150
Runway end elevation (feet above MSL)	433	347	430	363	415	356
Pavement type/friction	Concrete/grooved	Concrete/grooved	Concrete/grooved	Concrete/grooved	Concrete/grooved	Concrete/grooved
Pavement strength (000 pounds)						
Single gear	100(S)	100(S)	100(S)	100(S)	100(S)	100(S)
Dual gear	230(D)	230(D)	250(D)	200(D)	216(D)	216(D)
Dual tandem gear	600(2D)	600(2D)	550(2D)	350(2D)	448(2D)	448(2D)
Double dual tandem gear	1400(2D/2D2)	1400(2D/2D2)	1128(2D/2D2)	880(2D/2D2)	1157(2D/2D2)	1157(2D/2D2)
Runway markings	Precision	Precision	Precision	Precision	Precision	Precision
Runway lighting	HIRL	HIRL	HIRL	HIRL	HIRL	HIRL
Centerline lights	Yes	Yes	Yes	Yes	Yes	Yes
Approach lighting	ALSF-II	MALSR	ALSF-II	MALSR	ALSF-II	MALSR
Approach Aids	TDZ LOC GS PAPI	TDZ LOC GS PAPI	TDZ LOC GS PAPI	LOC GS PAPI	TDZ LOC GS PAPI	LOC GS PAPI
Instrument approach procedures	ILS (CAT I, II, IIIB) RNAV(GPS)	ILS (CAT I) RNAV(GPS)	ILS (CAT I, I, IIIB) RNAV(GPS)	ILS (CAT I) RNAV(GPS)	ILS (CAT I, II, IIIB) RNAV(GPS)	ILS (CAT I) RNAV(GPS)
Minimum approach decision height (feet above MSL)	n.a.	547	n.a.	580	n.a.	556
Minimum approach visibility	300 RVR	1800 RVR	300 RVR	2400 RVR	300 RVR	2400 RVR

Notes:
ALSF-2 = High-intensity approach light system with centerline sequenced flashers
CAT = Category
GPS = Global positioning system
GS = Glide slope
HIRL = High-intensity runway light
ILS = Instrument landing system
LOC = Localizer
MALSR = Medium-intensity approach light system with runway alignment indicator lights
MSL = Mean sea level
PAPI = Precision approach path indicator
RNAV = Area navigation
RVR = Runway visual range

Source: Port of Seattle, 2014. Updated May 2017.

Table 2-2
Taxiway Characteristics
Seattle-Tacoma International Airport

Taxiway designation	Type	Location	Width	Length	Exit geometry
A	Parallel	East side, north of Taxiway L, runs to Taxiway D	100	5,000	n.a.
B	Parallel	East side, from South Apron to North Apron	100	12,700	n.a.
C	Connector	North End, connecting Runways 16L, 16C, 16R	100	2,300	n.a.
D	Connector	North End, Taxiway B to Runway 16L-34R and 16C-34C	100	750	n.a.
E	Exit, Connector	North End, exiting for Runway 34L, connecting Taxiway T, Runway 16C-34C, 16L-34R and Taxiway B	100	2,600	30 degrees
F	Exit	North End, exiting from Runway 34C, to TW E	100	1,000	30 degrees
G	Connector	North end, east side, connecting Taxiway A and Taxiway B	100	150	n.a.
H	Exit	North End, exiting from Runway 34C & Runway 16L to Taxiway B	100	1,800	30 degrees
J	Exit, Connector	North End, exiting for Runway 34L, connecting to Taxiway T, exiting for Runway 16C and 16L to Taxiway B	100, 75	3,750	30 degrees 45 degrees
K	Exit	North End, exiting from Runway 34C to Taxiway J	100	1,100	30 degrees
L	Connector	East side, connecting Runway 16L-34R to Taxiway B	100	250	n.a.
M	Exit, Connector	South End, exiting Runway 16C, connecting Taxiway B	100	250	30 degrees
N	Exit, Connector	South End, exiting Runway 16R, connecting Taxiway T, exiting Runway 16C, connecting Taxiway B	100	3,100	45 degrees 30 degrees
P	Exit, Connector	South End exiting Runway 16R, connect to Taxiway T, exiting Runway 16C, connecting Taxiway B	100	3,700	30 degrees
Q	Exit, Connector	South End, exiting Runway 16R, connecting Taxiway T, exiting Runway 16C and Runway 16L connecting Taxiway B	100	3,550	30 degrees 90 degrees
R	Exit	South End, exiting Runway 16R, connecting Taxiway Q	100	400	90 degrees
S	Exit	South End, exiting Runway 16L	100	300	90 degrees
T	Parallel	West side, between Runways 16R-34L and 16C-34C from Taxiway C to Taxiway Q	100	9,300	n.a.
Z	Exit	Exiting Runway 34L, connecting Taxiway C	100	1,200	30 degrees

Notes:
Location Example For T/W C = North end connecting Runways 16L, 16C, 16R
North End = North of LAT 47d, 27m N
South End = South of LAT 47d, 27m N

Source: Port of Seattle; Seattle-Tacoma International Airport Layout Plan, 2007.

2.2.3 *Air Traffic Control and Airspace Constraints*

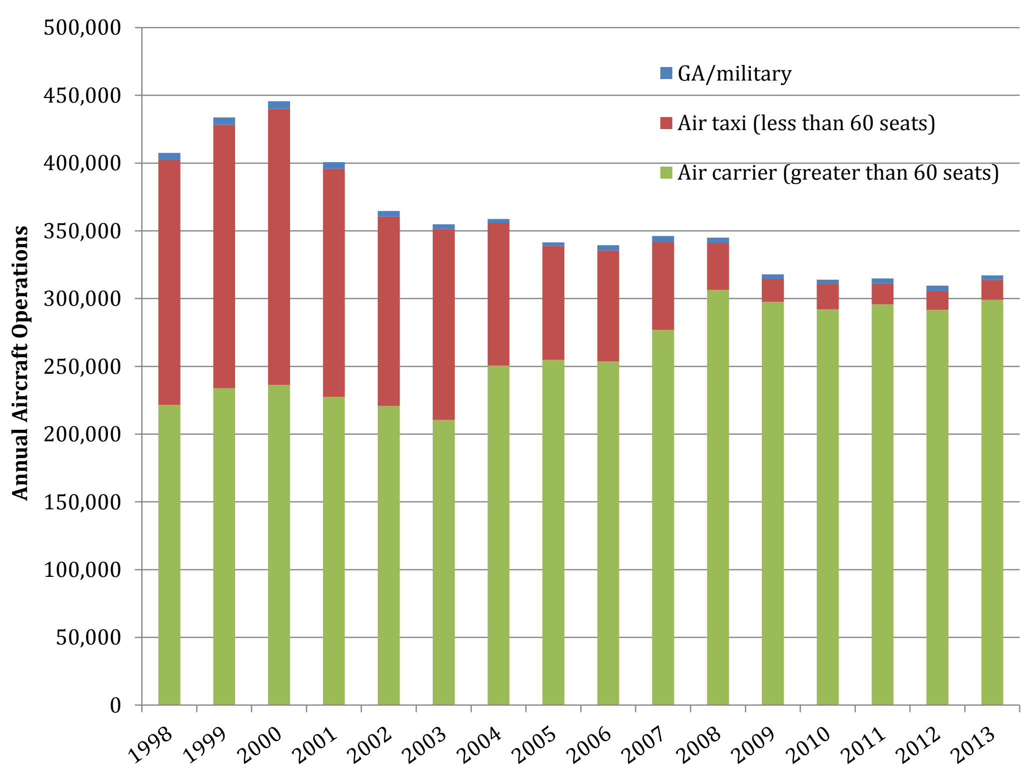
Several factors related to air traffic control procedures and physical facilities at the Airport reduce airfield capacity:

- **Divergent departures headings.** Departing aircraft are no longer permitted to "fan out" on divergent headings.
- **Noise corridors.** A noise "corridor" exists to both the north and south of the Airport. All departing aircraft must use these corridors.
- **Runway spacing.** The spacing between the Airport's runways requires dependent approaches in poor weather.

2.2.4 *Fleet Mix*

As shown on Figure 2-2, the types of aircraft using the Airport have changed greatly over the last 15 years. Specifically, smaller air taxi aircraft (those with 60 seats or less) have been replaced by larger air carrier narrow-body aircraft. In 2000, approximately half of the Airport's fleet mix consisted of narrow-body aircraft. Today, narrow-body aircraft make up over 90% of the Airport's fleet mix. This trend towards larger aircraft at the Airport has led to increases in required aircraft separation, resulting in decreased airfield capacity.

Figure 2-2
Changes in Fleet Mix: 1998-2013
Seattle-Tacoma International Airport



Source: LeighFisher analysis of ATADS data, 2015.

2.3 Airfield Facility Requirements

This section summarizes our assessment of facility requirements related to airfield capacity and compliance with FAA design criteria.

2.3.1 Runway Length Requirements

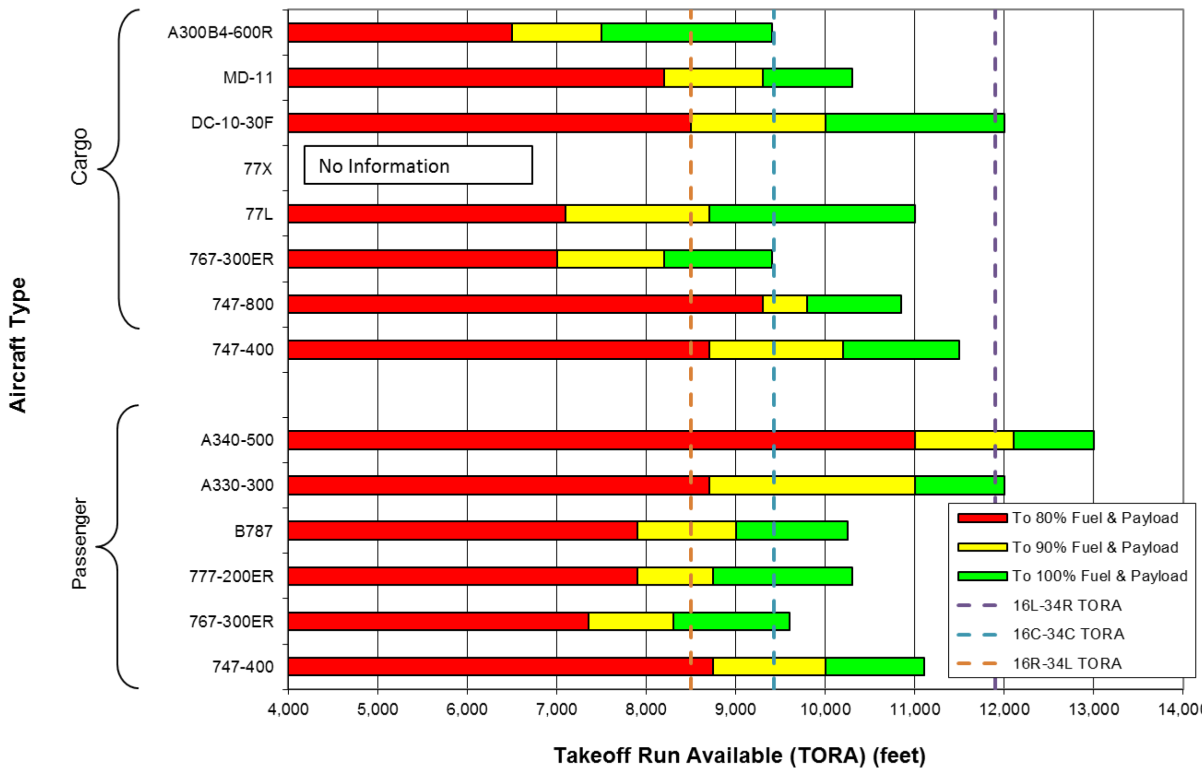
This section summarizes our assessment of takeoff runway length requirements for heavy aircraft (i.e., aircraft capable of operating at maximum weights in excess of 300,000 pounds). The Airport's runways are known to provide adequate takeoff length for non-heavy aircraft and adequate landing length. We anticipate that during subsequent planning it may be necessary to determine the minimum runway takeoff length required for a wider range of aircraft using airline-specific assumptions related to payload and range (e.g., when conducting detailed planning related to end-around taxiways). Such aircraft performance requirements will be determined at that time, with specific inputs from the airline stakeholders.

The assessment was conducted based on guidance provided in FAA *Advisory Circular 150/5325-4B Runway Length Recommendations* for Airport Design, information from documents titled *Airplane Characteristics for Airport Planning* published by Airbus Industries and the Boeing Company, and the following assumptions:

- Charts used were for standard day temperature + 15 ° C
  - Standard day temperature equals 14.4° C or 58° F
  - Standard day + 15 degrees equals 29.4° C or 85° F
  - The Airport's mean maximum daily temperature during the hottest month is 24° C, or 76 ° F
- Anticipated aircraft engine types
- Zero runway gradient and zero wind Sean?
- Airport elevation of 415 feet
- Heavy aircraft included in the design day flight schedules for PALs 1 through 4

Figure 2-3 presents the takeoff runway length requirements for the selected aircraft types. The lengths required are represented by bars, which are shaded to indicate the runway length necessary for the aircraft to take off at 80%, 90%, and 100% of maximum fuel and payload (i.e., passengers, baggage, and cargo). Based on the results shown, the only aircraft type studied that cannot takeoff at 100% fuel and payload (or, in the case of the A330-300, nearly 100%) is the A340-500. The longest route anticipated for the A340-500 is from Seattle to Frankfurt, Germany, and the number of operations forecast for that route is relatively small. Therefore, from the standpoint of aircraft performance, we conclude that the lengths of Airport's existing runways are adequate and there is no requirement for additional runway length.

Figure 2-3
Runway Departure Length Required for Heavy Aircraft – Standard Day +15° C
Seattle-Tacoma International Airport



Source: LeighFisher based on FAA guidance and data from aircraft manufacturers, June 2017.

2.3.2 Airfield Demand vs. Capacity Assessment and Requirements

This section provides a high-level summary of the previous capacity analyses as well as LeighFisher's airfield capacity assessment that was conducted in 2015 in cooperation with the FAA and Port of Seattle. Subsequent to the 2015 assessment, a number of changes occurred, largely as a result of the closure and reopening of the center runway (Runway 16C-34C), that significantly changed existing runway-use procedures and recommended assumptions for estimating the Airport's existing and future airfield capacity. To reflect these changes, the Port of Seattle decided to undertake an updated analysis (currently underway), which when completed, will supersede the 2015 airfield capacity assessment. The results of the updated airfield capacity assessment will be presented in Technical Memorandum No. 6 Alternatives.

2.3.2.1 Previous Capacity Analyses

In the last 15 years, there have been three airfield capacity analyses of the Airport's three-runway system:

- The 2002 *Airfield Simulation Study* estimated the Airport's capacity to be 587,000 annual operations, based upon the criterion of no more than 20 minutes of average aircraft delay.
- The 2004 *Comprehensive Development Plan* estimated maximum sustainable throughput of the three-runway system to be 110 operations per hour.
- The 2014 FAA *Airport Capacity Profile* for Seattle International Airport included a range of capacity estimates from 112 operations per hour in visual conditions to 76 operations per hour in instrument conditions.

2.3.2.2 Overview of the 2015 Airfield Capacity Assessment

The 2015 airfield capacity assessment included the following:

- Review of previous capacity analyses conducted for the Airport
- Development of an analytical (spreadsheet) assessment of airfield capacity and aircraft delay
- Simulation of airfield operations using the Total Airport and Airspace Modeler

For purposes of assessing airfield capacity, the primary performance metric used was average annual aircraft delay. In this context, delay represents *excess travel times* or *queuing delays* associated with sequencing aircraft arriving to or departing from the Airport.

2.3.2.3 Analytical Capacity Analyses

LeighFisher used industry-standard analytical models and methodologies for estimating hourly and annual airfield capacity and average aircraft delay.

Hourly Capacity

Hourly capacity of the existing airfield was assessed using the Airport Cooperative Research Program (ACRP) Prototype Airfield Capacity Spreadsheet Model, which was based on the industry-standard FAA Airfield Capacity Model (ACM), for Visual Meteorological Conditions, Marginal Visual Meteorological Conditions, and Instrument Meteorological Conditions.

Annual Service Volume

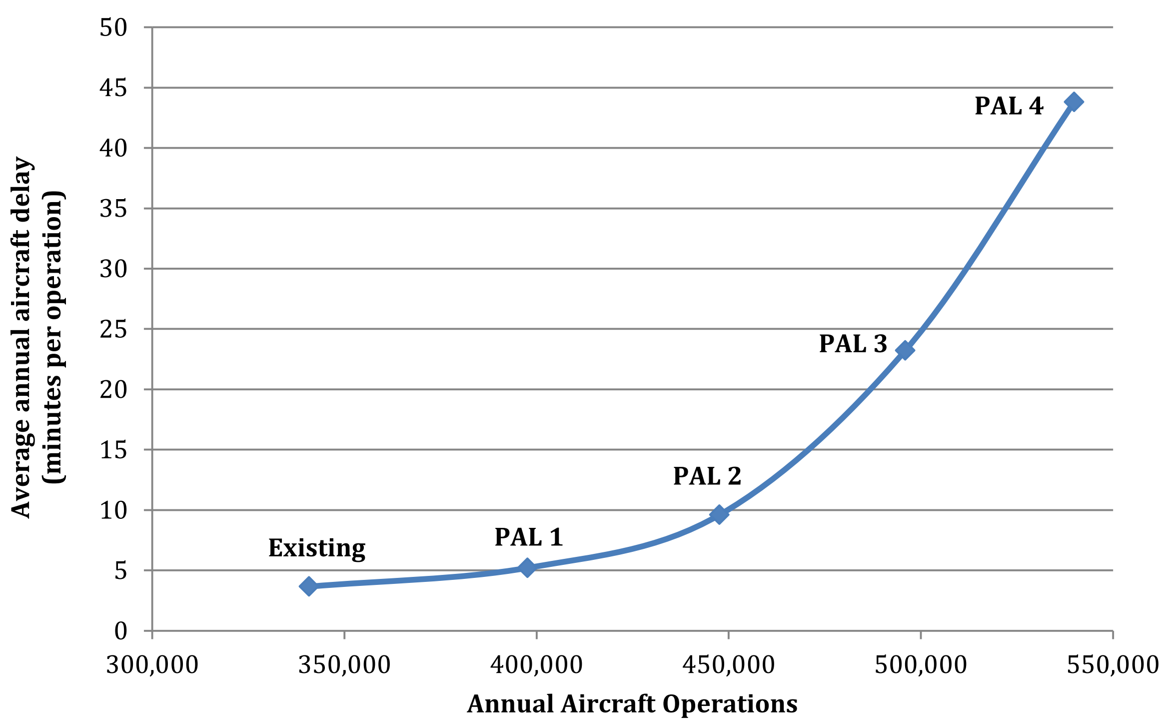
The Annual Service Volume (ASV) of the Airport was calculated. ASV is a reasonable estimate of the annual capacity of an airfield configuration. ASV is not a "hard upper limit"; rather, it has been established in practice that as the level of actual annual aircraft operations approaches ASV, additional increases in aircraft operations result in disproportionate increases in aircraft delays. ASV typically equates to about 4 to 6 minutes of average annual delay per aircraft movement. ASV takes into account differences in runway utilization, weather conditions, and aircraft fleet mix.

Average Annual Aircraft Delay

Average annual delay was calculated using the FAA Annual Delay Model (ADM), which had been updated in 2011 under a research project sponsored by NASA. Inputs to the ADM included (1) distribution of aircraft operations over months of the year, days of the week, and hours of the day; (2) the percent arrivals over the hours of the day; (3) the percent occurrence of the various runway configurations and weather conditions; and (4) the arrival- and departure-priority hourly airfield capacities for each of the runway-use configurations and weather conditions.

Figure 2-4 depicts the estimated average annual aircraft delay associated with each future annual demand level (i.e., PAL). The delays shown represent the estimated average annual delay levels that would be incurred if future demand levels were to materialize and no procedural improvements or capacity enhancements to the existing airfield were made.

Figure 2-4
Annual Demand / Capacity Comparison
Seattle-Tacoma International Airport



Source: LeighFisher analyses, 2015.

2.3.2.4 Airfield Simulation

Airfield simulation analyses were completed using the Total Airspace and Airport Modeler (TAAM) to evaluate the performance of the existing airfield and to identify the areas on the airfield that limit the capacity and contribute to airfield congestion and delay.

TAAM experiments were run for the existing airfield layout using design day flight schedules for baseline conditions (2014) and forecast levels of activity expected for 2024 (PAL2) and 2029 (PAL3). The assumptions and results from the TAAM simulation analysis are summarized in the January 2016 memorandum titled *Airfield Simulation Modeling Assumptions and Findings*.

The results of the analytical capacity analyses indicated that the existing airfield could likely accommodate forecast activity between PAL2 and PAL3 with average delays of 10 minutes per operation at PAL2 and 23 minutes per operation at PAL3 (refer to Figure 2-3). However, these estimates considered mainly the runway capacity constraints with the implicit representation of the taxiway and airspace constraints represented through assumed aircraft separations and runway-occupancy times.. TAAM explicitly considers how the Airport taxiway system, the apron/gate area, and the airspace will affect airfield capacity and aircraft delay.

Results from the TAAM simulation analysis indicated that (1) PAL2 (2024) demand can be accommodated at an acceptable level of delay without improvements, and (2) PAL3 (2029) demand can be accommodated with average annual aircraft delays of either 16.1 minutes or 20.7 minutes, depending on the method used to assess the relative frequency of visual versus instrument weather conditions.

2.3.2.5 Conclusions and Requirements

Several high-level conclusions from the 2015 assessment are still valid, including the following:

- With no facilities or operational improvements, average annual aircraft delay will likely exceed 20 minutes by PAL 3 (2029). This is an unacceptable level of delay.
- Aircraft delays are attributed not only to the Airport's runway system, but also to the Airport's apron-gate area (or non-movement area), taxiway/hold pad system (or movement area), and airspace restrictions—shortcomings in all these system components contribute to aircraft delay.
- Fundamental changes in airfield facilities and airfield / airspace operating strategies will be needed throughout the planning period to reduce delay to acceptable levels.

The requirement, for both PAL 3 (2029) and PAL 4 (2034), is to identify a range of physical and procedural improvements that will allow the airport's airfield and airspace to be operated more effectively.

At the time this *Technical Memorandum No. 5 – Facility Requirements* was prepared, a number of changes to the airfield operating system, including runway use and the demand profile, have occurred that could affect the aircraft delay estimates resulting from the 2015 airfield capacity assessment. In addition, key assumptions related to operating rules that have a significant impact on capacity and delay (e.g., a waiver for the adverse runway stagger in north flow and the hourly estimated capacities in the 2014 FAA *Airport Capacity Profiles*) have also changed. Therefore, the planning team and FAA are continuing to assess these and other relevant factors that could influence conclusions regarding the level of average annual delays expected to occur during the planning period.

2.3.3 FAA Design Criteria Compliance Review

This section describes our assessment of the Airport's existing airfield layout, signage, and lighting for compliance with current FAA design criteria.

2.3.3.1 Design Criteria

Applicable design criteria were obtained from FAA Advisory Circulars, Engineering Briefs, and Orders, including the following:

- FAA *Advisory Circular 150/5300-13A , Airport Design*
- FAA *Advisory Circular 150/5340-30H, Design and Installation Details for Aircraft Visual Aids*
- FAA *Engineering Brief 78, Linear Equations for Evaluating the Separation of Airplane Design Groups on Parallel Taxiways and Taxiways to Fixed/Movable Objects*

2.3.3.2 Existing Modifications to Standards

Airfield components which do not meet current FAA airport design standards but have been accepted by the FAA through the issuance of a modification to airport design standards are shown in Table 2-3.

2.3.3.3 Design Aircraft

The design aircraft is defined in FAA *Advisory Circular 150/5300-13A, Airport Design* as having characteristics that determine the application of airport design standards for a specific runway, taxiway, taxilane, apron, or other facility. This aircraft can be a specific aircraft model or a composite of several aircraft using, expected, or intended to use the airport or part of the airport. The Advisory Circular does not specify a minimum threshold level of operations required for an aircraft type to be designated the design aircraft. Instead, the determination of the design aircraft is left to the airport operator's discretion, so long as design is not based on a design aircraft expected to use an airport "infrequently".

In *Technical Memorandum No. 2 – Aviation Activity Forecasts*, LeighFisher identified the design aircraft based on the most demanding aircraft in terms of Main Gear Width (MGW) and distance from Cockpit to Main Gear (CMG) in the forecast fleet mix as the B777-300, which is classified as an Airplane Design Group (ADG) V/ Taxiway Design Group (TDG) 6. For analysis of the existing taxiway geometry and areas of potential fillet widening, the B777-300 was used. For analysis of existing airfield geometry including taxiway separation and potential Object Free Area (OFA) conflicts the ADG V, B747-400 was used because of its wingspan and tail height. Exterior dimensions for the Boeing 777-300 and 747-400 aircraft are illustrated in Figure 2-5.

Table 2-3
Existing Modifications to Design Standards
Seattle-Tacoma International Airport

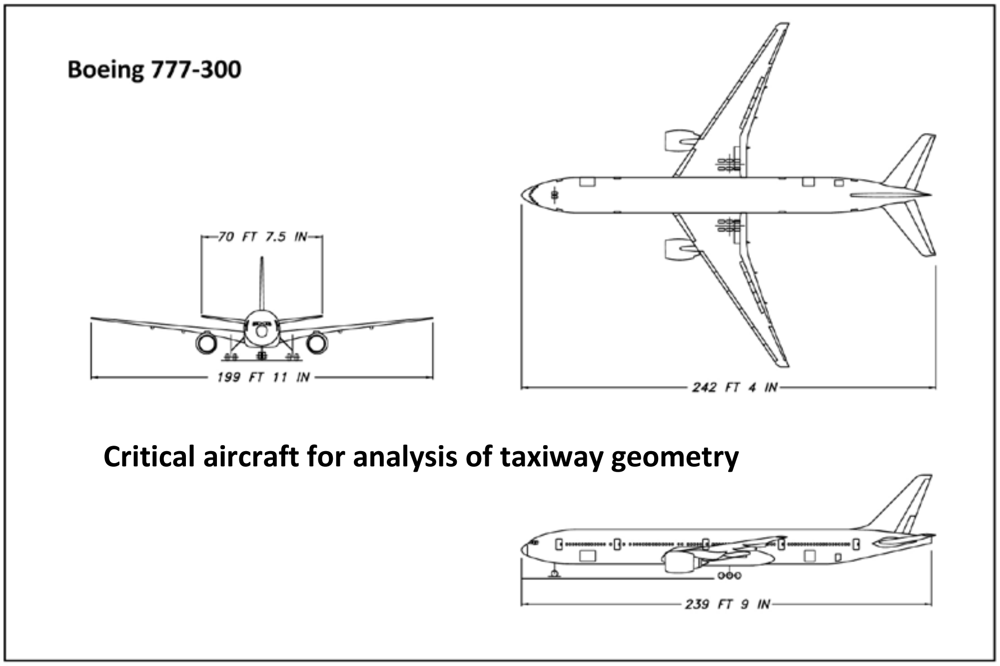
Design element	Standard	Existing Condition	Cause of Condition	Mitigation Justifying Modification to Standards	Date Issued
FAA Part 77 - Aircraft Parked at Concourses B&C	No surface penetration	Aircraft tails penetrate 7:1 primary surface	Runway/terminal proximity	None	1/16/1981
FAA Part 77 - Aircraft Parked at N&S Satellites	No surface penetration	Aircraft tails penetrate 7:1 primary surface	Runway/terminal proximity	None	1/16/1981
FAR Part 77 Surfaces - Parked A/C at Concourse B, C, N & S Satellites	No Surface Penetration	Vertical tail sections penetrate	Terminal location	None	1/16/1981
Taxiway A Object Free Area	160 feet from centerline to fixed or moveable object (ADG V)	154 feet on east side	Retaining wall along service road	None	12/21/1987
FAA Part 77 - Aircraft Parked at Concourses B&C	No surface penetration	Light standards penetrate 7:1 primary surface	Runway/terminal proximity	None	9/13/1990
FAR Pat 77 Surfaces - Light Standards on Concourse B&C	No Surface Penetration	Standards penetrate by 34 feet	Terminal location	None	9/13/1990
Runway 16L Pavement Crown	On centerline	Offset 25 feet to 50 feet east	Original runway construction	None	4/15/1992
Surface markings - Taxiway H & J Holdlines	Perpendicular to taxiway centerlines	Parallel to runway centerline	Taxiway geometry	None	5/20/1992
Surface Markings - Taxiway Holdlines H&J (Old B2&B3)	Perpendicular to TW centerlines	Parallel to runway centerline	Taxiway geometry	None	5/20/1992
Low Visibility Taxiway Lighting System	5 -foot intervals between clearance bar lights	10 foot intervals between clearance bar lights	Installed prior to AC publication	None	10/4/2002
Low Visibility Taxiway Lighting System	Non-standard installation of lights		Installed for demo project prior to AC publication	None	10/4/2002
Taxiway Centerline Light Lead Off Lights	No lead off lights above 1200-foot RVR	No edge lights installed, need centerline lights	Lighting system design	None	2/14/2008
Taxiway Centerline Lights Color Coded Inside Runway Holdlines	Color coding inside runway holdlines and ILS holdlines	Color code only inside Runway holdlines	Taxiway Geometry	None	2/14/2008
B747-8 Operational Plan – Runway 16L/34R-Taxiway B Separation	550 feet for ARC D-VI	400 feet	B747-8 larger wingspans	All B747 must use Taxiway A during low-visibility conditions	12/2/2008
B747-8 Operational Plan - Taxiway A&B Object Free Area Width	386 feet for ARC D-VI	300 feet	B747-8 larger wingspans	Calculate OFA using formula per aircraft instead of entire Group standard	12/2/2008
B747-8 Operational Plan - Taxiway C&D Wingtip Clearance BTN Runway 16L/34R and 16C/34C	62 feet wingtip clearance	54.88 feet	B747-8 larger wingspans	Calculate wingtip clearance using formula per aircraft instead of entire Group standard and limit other aircraft when the B747-8 is on either C or D taxiways	12/2/2008
B747-8 Operational Plan - Taxiway C&D Wingtip Clearance at North Hold Apron	62 feet wingtip clearance	54.88 feet	B747-8 larger wingspans	Calculate OFA using formula per aircraft instead of entire Group standard	12/2/2008
B747-8 Operational Plan - Taxiway B & Taxilane W Wingtip Clearance	62 feet wingtip clearance	42.3 feet	B747-8 larger wingspans	Allowed under approved MOD	12/2/2008
B747-8 Operational Plan - Taxiway Fillet Dimensions	Group VI	Group V	B747-8 larger wingspans	None	12/3/2008
Taxiway B Wingtip Clearance to Vehicle Service Road	193 feet for ARC D-VI	167 feet	B747-8 larger wingspans	The POS will move a section of the road	12/4/2008
Taxiway Q OFA at FBO	386 feet for ARC D-VI	320 feet	B747-8 larger wingspans	Calculate OFA using formula per aircraft instead of entire Group standard	12/5/2008

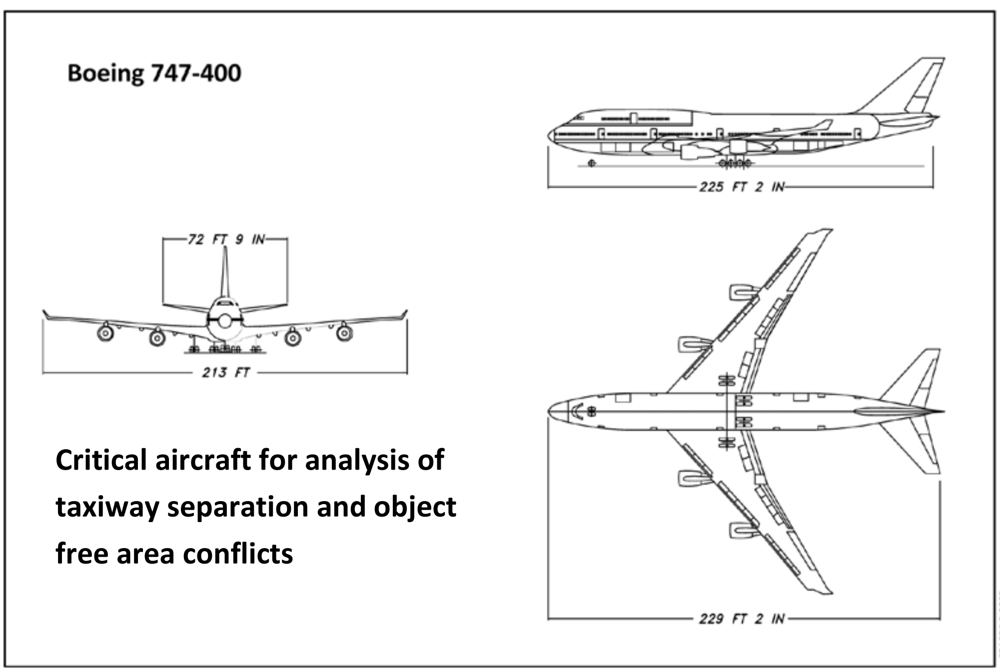
Table 2-3 *(continued)*
Existing Modifications to Design Standards
Seattle-Tacoma International Airport

Design element	Standard	Existing Condition	Cause of Condition	Mitigation Justifying Modification to Standards	Date Issued
Taxiway A & Retaining Wall/Vehicle Service Road	62 feet wingtip clearance	54 feet	B747-8 larger wingspans	Calculate OFA using formula per aircraft instead of entire Group standard	12/6/2008
Runway Width & Blast Pad Sizes, All Runways	200-foot Runway with 40-foot shoulders. Blast Pads 280 feet wide by 400 feet long	All runways 150 feet wide. Runway 16L & 16R shoulders are standard 35 feet. Runway 16C shoulders are 25 feet. Blast Pad sizes vary per Runway end.	SEA is an ADV V airport. All runways meet ADV V dimensions. Runway 16L & 16R shoulders meet ADV V dimensions. RUNWAY 16C shoulders were constructed in 1972, under different standards. No clear requirement for standard pad sizes.	Increase Runway 16C shoulders to 35 feet when RUNWAY is reconstructed in 2016	8/18/2011
Taxilane W Separation	AC 150/5300-13a	Taxilane W is restricted to aircraft with 125-foot wingspans.	B767-300ER wingspans	Relocate Taxilane W centerline 13 feet to the east and the vehicle service road 17 feet to the east, to allow for the larger wingspan	12/12/2013
Taxiway B-Taxilane W Separation & Taxilane to Fixed or Movable Object Separation south of Taxiway N	232 feet and 113 feet plus submittal of a modification of airport design standards	232 feet & 113 feet	Need to allow B767-300ER with winglets to operate on Taxilane W	Relocate Taxilane W centerline 13 feet east and the vehicle service road 17 feet east	2/25/2014
Transverse Grades in the RSA (Runway 16C-34C)	1.5-inch drop from the shoulder edge followed by a 5% drop for 10 feet, followed by a 1.5% to 3% variable grade to RSA and then a 16:1 grade for 107 feet past the RSA	Existing grades adequately drain.	NA	None	4/25/2014
Runway 16C-34C Pipe for Storm Drains and Culverts	Pipes must be constructed using Concrete, PVC, or HDPE	Use of ductile iron storm drain pipe beneath the runways and taxiways	Port had previous issues with cracks and defects in concrete pipe	None	1/15/2015
WSDOT Specifications for Gravel Backfill for Pipe Bedding in Unpaved Areas (Runway 16C-34C)	Material backfill material as specified in D-701-3.5	WSDOT gravel backfill for pipe zone bedding in pipe zone for non-paved areas	It is not economical to use P-153 CLSM in non-paved areas	None	1/27/2015
Modification of FAA Specifications for Better Quality Control of Concrete Aggregate (Runway 16C-34C)	Provisions in P-501 require testing for delirious material only in the proposed design mix	Test for deleterious substances as part of the mix design, and during concrete production for each lot of concrete. Submit test reports within 21 days of placement.	Issues with pop-outs on Runway 16R-34L	None	1/28/2015
Longitudinal Profile with Vertical Curve Placement Within the Last 25% of End of Runway 16C-34C	No grade changes are allowed in the first and last quarter of the runway length	Grade of 0.36% and then 0.80% with associated grade break, smoothed by way of a 1,600-foot vertical curve	Extensive reconstruction and grading would be needed	None	4/22/2015
Runway 16L-34R Separation to Parallel Taxiway B	Approach Reference Code—D-V Runway to Taxiway separation is 500 feet; D-VI Runway to Taxiway separation is 550 feet Departure Reference Code-- Runway to Taxiway separation is 500 feet for unrestricted operations and 400 feet for restricted operations by ADG-VI aircraft	Runway to Taxiway separation is 400 feet north of Taxiway S	Taxiway B cannot be relocated at this time because of impacts to adjacent facilities	Letter of agreement (LOA) with Seattle Airport Traffic Control Tower (ATCT) and Port of Seattle Ramp Tower (SRT), and ATCT standard operational procedures will facilitate control of aircraft movements on Taxiway B and avoid limiting approaches to Runway 16L-34R in any way. LOA will include procedures where ATCT will advise SRT when RVR drops below 2400 and then airlines will request a 30-minute Prior Permission Required (PPR) from the SRT. This will permit the SRT to plan movements to meet requirements and communicate with ATCT. Operational procedures to separate aircraft will be documented in a LOA between the ATCT and SRT.	12/21/17

Source: Port of Seattle, 2017.

Figure 2-5
Design Aircraft Dimensions
Seattle-Tacoma International Airport





Source: Boeing CAD 3-View Drawings for Airport Planning Purposes.

The design aircraft is classified by three parameters: Aircraft Approach Category (AAC), ADG, and TDG. The AAC categorizes aircraft according to their typical approach speeds and is denoted with letters ranging from "A" to "E," in order of increasing approach speed. The ADG categorizes aircraft according to wingspan and tail height and is denoted with Roman numerals ranging from "I" to "VI", in order of increasing wingspan. While ADG classifies aircraft according wingspan and tail height, it does not account for the critical dimensions of the undercarriage. The design of fillets is established using the TDG which classifies aircraft by their maximum gross weight and cockpit-to-main gear distance. The design aircraft classifications for the Airport are shown in Table 2-4.

Table 2-4
Design Aircraft Classifications for Approach Category, Airplane Design Group, and Taxiway Design Group
Seattle-Tacoma International Airport

Parameter	Design aircraft classification
Aircraft Approach Category (AAC)	D
Airplane Design Group (ADG)	V
Taxiway Design Group (TDG)	6

Source: LeighFisher, September 2015.

2.3.3.4 Results of Compliance Review

The results of the airfield compliance review revealed several issues of non-compliance with design criteria and, therefore, required improvements. These issues and requirements are discussed below.

Compliance Issue #1: Separation Between Runway 16L-34R and Taxiway B

FAA Advisory Circular 150/5300-13A specifies that the separation required between the centerline of Runway 16L-34R and the centerline of Taxiway B is 500 feet. The existing separation is 400 feet. The basis of the requirement is Aircraft Design Group V aircraft related to arrivals in visibility conditions less than 2,400 feet (runway visual range).

The FAA's expectations are that:

- There will be no further expansion, beyond what has already been approved by the FAA's Seattle Airports District Office, to impede Runway 16L-34R from meeting the permanent runway-to-taxiway separation standard of 500 feet.
- As opportunities arise to reduce the existing penetrations of the 500 foot standard the Port will take steps to implement the standard separation distance at those locations.
- Until the permanent separation distance standard is met for the full length of the runway and parallel taxiway, the Port will use operational procedures documented by an approved FAA Modification to Standard to meet the separation standard.

- Within three years, the Port shall initiate a study specifically designed to develop a plan for fully meeting this separation standard in the long term.

Compliance Issue #2: Existing Airfield Intersection Geometry for Design Aircraft

The Airport's existing airfield, as at many U.S. airports, was designed and constructed in accordance with Advisory Circular 150/5300-13, before the introduction of today's wide body aircraft. The FAA updated the Advisory Circular to 13A in September 2012, and updated it again with Change 1 in February 2014. The main focus of these updates was reducing the amount of pavement required in taxiway intersections.

We analyzed the airfield's taxiway intersections using computer-aided aircraft modeling. Figure 2-6 identifies those which taxiway intersections will require fillet widening in order to provide the 15' Taxiway Edge Safety Margin (TESM) required for the turning movements of the B777-300 design aircraft. Those intersections with deficient fillets involve the intersection of Taxiway B with the following:

- Runway 34R
- Taxiway D
- Taxiway E
- Taxiway H
- Taxiway K
- Taxiway M
- Taxiway N
- Taxiway Q

The FAA recommends that the Port meet standards when reconstruction projects are required in those areas where intersections with deficient fillets have been identified or undertake a project when there seems to be a problem.

Figure 2-6
Taxiway Intersections Where Fillet Widening is Required to Meet Standards for Boeing 777-300 Turning Movements
Seattle-Tacoma International Airport

Source: CH2M Hill, Engineers, February 2016.

Compliance Issue #3: Runway Blast Pad Geometry

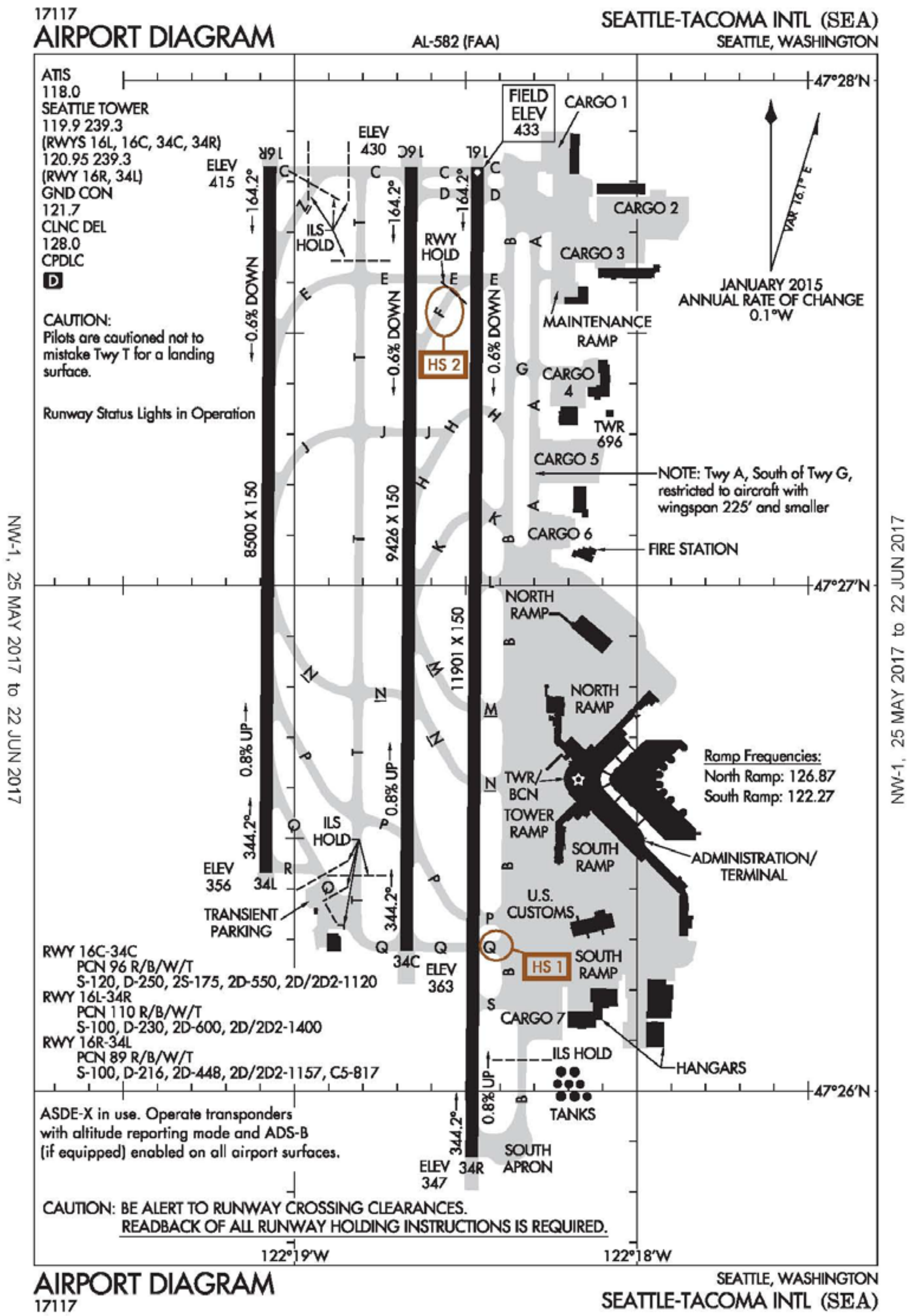
Advisory Circular 150/5300-13A specifies that runway blast pads for Group V aircraft should be 220 feet wide and 400 feet long. As of February 2016, the blast pads for Runway 16R-34L are too small and require enlarging (each of the blast pads is 200 feet wide and 200 feet long). Additional pavement (20' width, 200' length) is required based on AC 150/5300-13A, Change 1, and will be depicted on the updated ALP.

The non-standard blast pad geometry should (1) be corrected with the next FAA funded project for Runway 16R-34L or when there is a significant change in use for this runway, and (2) be documented with an FAA Modification of Standards that records the rationale to leave the blast pads as they currently exist for some period of time.

Compliance Issue #4: Runway Incursion Mitigation & Hot Spot Locations

A Runway Incursion Mitigation (RIM) location is identified by the FAA and defined as a primary contributing factor for runway incursions based on historic runway incursion data. Hot Spot locations are airfield geometry on an airport movement area with a history of potential risk of collision or runway incursion, and where heightened attention by pilots and drivers is necessary. Hot Spot locations can be identified by the Airport or airport users. In some instances RIM locations and Hot Spots may overlap. The FAA has identified three RIM locations at the Airport, two of which overlap the two Airport/user identified Hot Spots. The locations of the Hot Spots, SEA-HS 1 and SEA-HS 2, are shown in Figure 2-7. SEA-HS 1 and SEA-HS 2 are also FAA identified RIM locations.

Figure 2-7
FAA Airport Diagram Identifying Airport Hot Spots
Seattle-Tacoma International Airport



Source: FAA Airport Diagram, June 2017 (Downloaded from Airnav.com in May 2017)

The third RIM location, which is not identified as a Hot Spot, is located at the confluence of Taxiway A, B, C, D in the northeast corner of the movement area.

Among all airfield geometric issues, the FAA assigns RIM locations the highest priority for mitigation. Accordingly, the cost for designing and constructing solutions to RIM locations should be included in the Airport's capital improvement program.

FAA RIM SEA-HS 1

FAA RIM SEA-HS 1 has been an area on the airfield where runway incursions have occurred in the past. According to the FAA, aircraft taxiing to the end of Runway 34C via Taxiway Q sometimes enter the Runway 34R safety area without authorization. The RIM program's records of conversation between pilots and air traffic controllers indicate two issues. The first issue is a propensity for pilots to interpret taxiing instructions to the end of Runway 34C as a direct action from Taxiway B. The second issue is a tendency for aircraft to pass over the hold line slightly when taxiing to the south on Taxiway B and turning west on Taxiway Q. According to the FAA, several matters may be contributing to the pilots either rolling over the Runway 34C hold marking or overshooting it slightly.

- Using the center runway as the primary departure runway is atypical. The practice at most airports is to use the inboard runway as the primary departure runway. Having to cross a runway to reach the primary departure runway is unexpected.

- Pilots are unable to turn onto Taxiway Q from Taxiway B and stop their aircraft with centerlines perpendicular to the hold position marking (insufficient distance between the hold marking and Taxiway centerline)—a position that affords maximum visibility of markings and traffic. This makes it difficult for the pilot to see the marking.

- The width of the taxiway could contribute to pilots having difficulty seeing the hold sign and the existing elevated runway guard lights on the south side of the taxiway hold position.

The requirement is to identify additional mitigation measures and the preferred alternative for improving this area.

FAA RIM SEA-HS 2

FAA RIM / SEA HS 2 is an area on the airfield where aircraft sometimes exit Runaway 34C on Taxiway F and proceed past hold position marking for Runway 16L-34R without authorization. Information from the Aviation Safety Reporting System database suggests that pilots do not always see the hold position marking. The reasons for not seeing the marking may be that the pilots are not expecting to exit directly onto another runway or that their exit speed was inconsistent with the exit configuration.

The requirement is to identify the preferred alternative for resolving this issue.

FAA RIM Additional Location

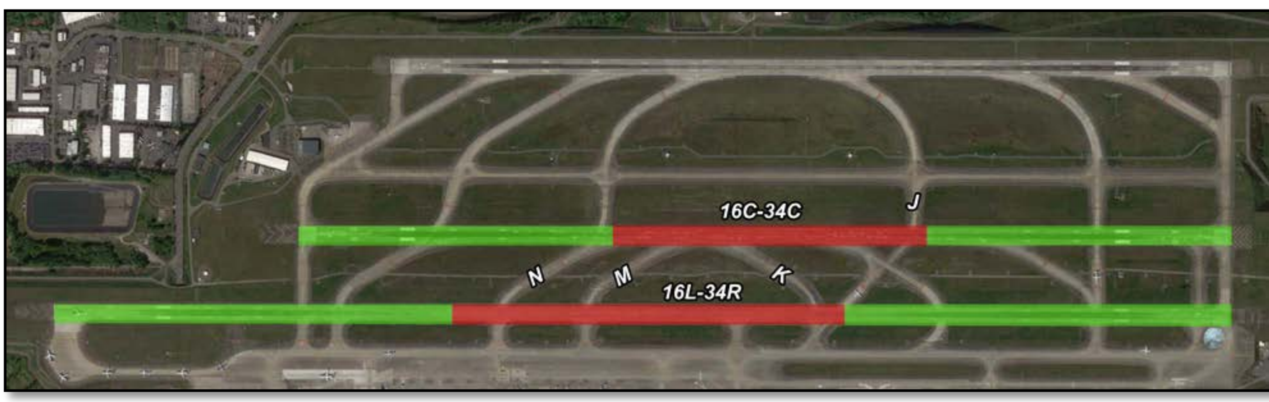
The Third FAA RIM is an area on the airfield where aircraft queue for departures on Runway 16L and 16C. Reports indicate that aircraft may be crossing the Runway 16L hold line as a result of the wide expanse of pavement or angled sweeping nature of Taxiway A. The requirement is to identify the preferred alternative for resolving this issue

Compliance Issue #5: High Energy Intersections

AC 150/5300-13A Section 401.b.5.d discusses the need to avoid "high energy" runway-taxiway intersections. The "high energy" portion of a runway is the middle third, where a pilot can least maneuver to avoid a collision. High energy runway-taxiway intersections are intersections that occur in the high-energy portion of a runway.

As shown on Figure 2-8, Runway 16C-34C and Runway 16L-34R each has at least one high-energy runway-taxiway crossing. Taxiways K, M, and N each cross Runway 16L-34R in the middle third, and Taxiway J is just within the middle third of Runway 16C-34C. The requirement is to follow up with a future analysis outside of this master plan update that will evaluate locations, capacity, and need.

Figure 2-8
High Energy Runway-Taxiway Intersections
Seattle-Tacoma International Airport



Legend

High-energy portion of runway

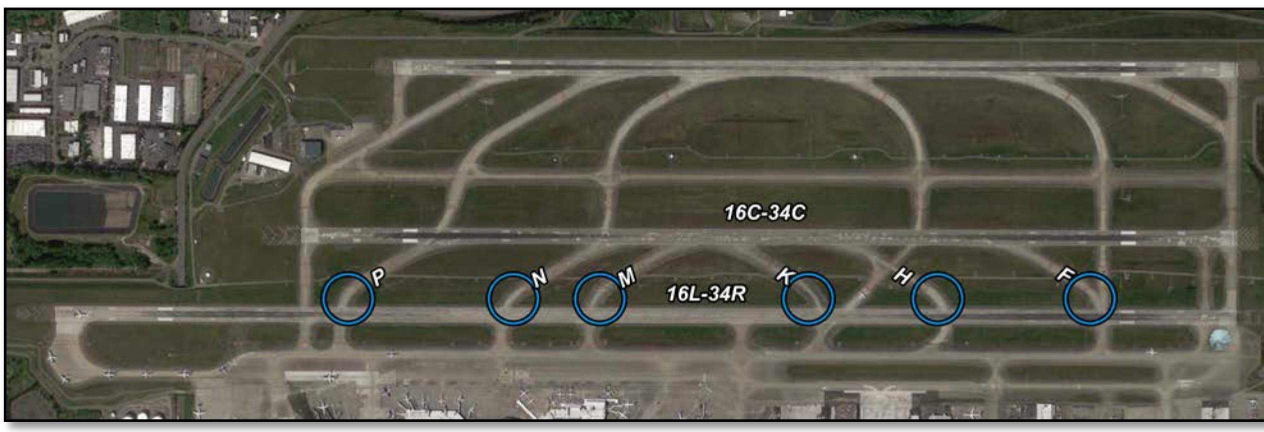
Source: CH2M Hill, Engineers, February 2016.

Compliance Issue #6: Right Angle Intersections

Advisory Circular 150/5300-13A Section 401.b.5.e discusses the use of right angle intersections as a method of increasing visibility both between taxiways and between taxiways and runways.
Section 401.b.5.e states that "Acute angle runway exits provide for greater efficiency in runway usage, but should not be used as runway entrance or crossing points."

The acute angle taxiways exiting Runway 16C-34C, shown in Figure 2-9, currently route exiting aircraft directly across Runway 16L-34R due to the lack of a parallel taxiway. While the acute angle taxiways do cross the runway centerline at a 90 degree angle, due to the alignment and wide radius of the taxiways transitioning from the acute angle to the right angle, aircraft approaching the runway hold lines for Runway 16L-34R are aligned on the acute angle and therefore have reduced visibility of the runway they are approaching. Since the length of the angled taxiways is currently used for queuing aircraft and is dependent on runway separation, this condition needs to be examined in the context of the entire airfield. Similar conditions exist where Taxiway P meets Runway 16C-34C on its west side, and where Taxiway C enters Runway 16L. As noted under Compliance Issue #4, Taxiway C will be examined further in this master plan update. Taxiway P west of Runway 16C-34C and the connectors between Runway 16C-34C and Runway 16L-34R require further consideration in future airfield planning outside of this master plan update.

Figure 2-9
Right Angle Intersections
Seattle-Tacoma International Airport



Source: CH2M Hill, Engineers, February 2016.

Compliance Issue #7: Direct Access to Runway from an Apron

Advisory Circular 150/5300-13A Section 401.b.5.g incorporates runway incursion mitigation guidance originally presented in FAA Engineering Brief 75 regarding taxiways which provide direct access to runways from parking aprons. The guidance states "Do not design taxiways to lead directly from an apron to a runway without requiring a turn."

Runway 16L-34R is served by parallel Taxiway B. Due to the proximity of the terminal to Runway 16L-34R, the portion of Taxiway B from Taxiway K to Taxiway S abuts the terminal apron. The terminal apron is served by Taxilane W, which runs parallel to the abutted portion of Taxiway B described above. Aircraft departing terminal gates taxi to Taxilane W and then turn onto Taxiway B at one of 5 crossover points to taxi to their departure threshold. Two of these crossover points are collocated with Runway 16L-34R exit taxiways, one at Taxiway L and one at Taxiway N, and therefore provide direct access to Runway 16L-34R, as illustrated in Figure 2-10. Taxiway L is going to be relocated in a 2018 capital improvement project. Relocation of the taxiway A-B crossover at Taxiway N will be considered during future pavement reconstruction in this area which is outside of the master planning period ,

Figure 2-10
Connector Taxiways with Direct Access to a Runway from an Apron
Seattle-Tacoma International Airport

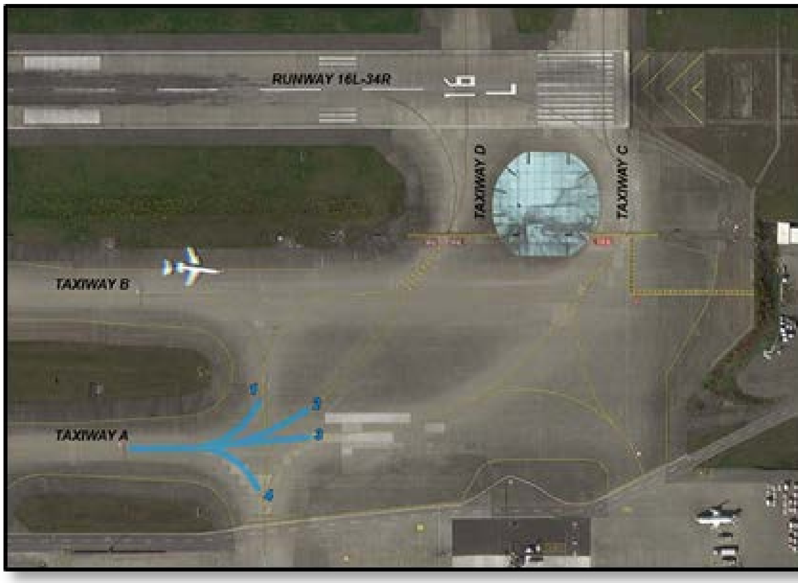
Source: CH2M Hill, Engineers, February 2016.

Compliance Issue #8: Three-Node Concept

Advisory Circular 150/5300-13A Section 401.b.3 discusses reducing pilot confusion by utilizing a three-node concept for taxiway intersections. This three-node concept is based on reducing complex intersections by limiting a pilot to no more than three choices when entering an intersection.

Currently, the only intersection not adhering to the three-node concept occurs on Taxiway A at its intersection with Taxiways C and D near the Runway 16L threshold as shown below in Figure 2-11. A preferred solution for reconfiguring this intersection as soon as possible is required

Figure 2-11
Taxiway A Intersection Inconsistent with Three-Node Concept
Seattle-Tacoma International Airport

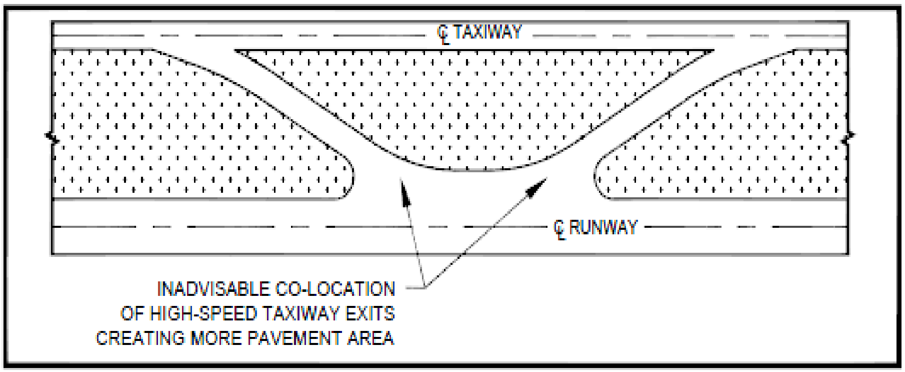


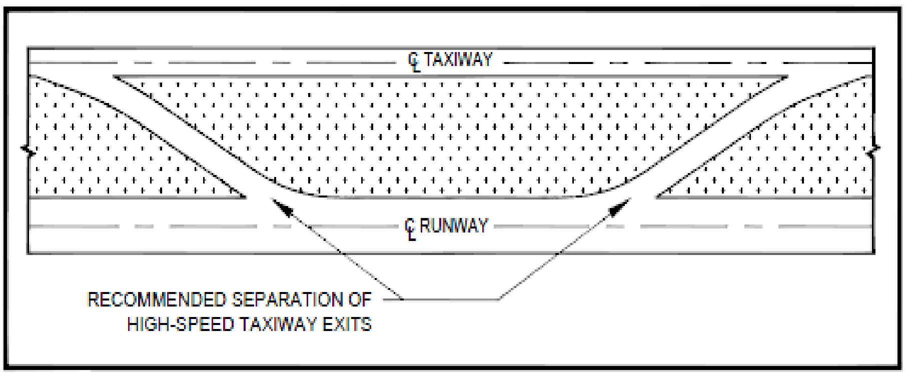
Source: CH2M Hill, Engineers, February 2016.

Compliance Issue #9: High Speed Exit Placement

Advisory Circular 150/5300-13A Section 409.e discusses the placement of exit taxiways and provides two figures which illustrate the poor design and proper design of high speed exit taxiways, as shown on the Figure 2-12. A preferred solution for reconfiguring these exits will be determined when examining the exits for Compliance Issue #5, High Energy Intersections, in a future analysis to be undertaken outside of this master plan update.

Figure 2-12
Illustrations from Advisory Circular 150/5300-13A of Poor and Proper Design of High-Speed Exits
Seattle-Tacoma International Airport





Source: FAA Advisory Circular 150/5300-13A.

Compliance Issue #10: No-Taxi Islands

Runway 34R is accessed by an entrance taxiway and a bypass taxiway from the hold pad near the threshold. Advisory Circular 150/5340-1L states that "Recorded runway incursion data associated with multi-taxi entrance designs to a runway that do not use "NO-TAXI islands" between the adjacent taxiway entrances have experienced a higher rate of runway incursions as compared to entrances with NO-TAXI islands." To reduce the possibility of runway incursions, all designs for a direct entrance to a runway that use two or more taxiway entrances must use "NO-TAXI islands" that are outlined with the continuous taxiway edge marking. A preferred solution for installing a NO-TAXI island between the Runway 34R threshold and its adjacent entrance and bypass taxiways is required. The solution should be implemented as quickly as possible (resolution of this issue is currently included as part of the Taxiway A/Taxiway B south project which is anticipated to be one of the first projects implemented upon obtaining the necessary environmental approvals). Both the entrance and bypass taxiways should be designated by separate names.

Passenger Terminal

This chapter presents assessments of existing passenger terminal facilities and summarizes the requirements that must be satisfied to accommodate the aviation activity forecast through the 20-year planning period.

3.1 Introduction

Our assessments of passenger terminal facilities and requirements analyses included eleven passenger terminal functions:

- Passenger circulation
- Airline check-in and bag drop
- Passenger security screening
- Holdrooms
- Gates
- Concessions
- Public toilets
- Baggage handling systems
- Domestic bag claim
- Satellite Transit System
- U.S. Customs and Border Protection facilities

3.2 Existing Facilities and Operations

The Airport's passenger facilities consist of a single landside passenger terminal, airside Concourses A through D, the airside South Satellite, and the airside North Satellite. Currently all International arriving passengers are processed through immigration and customs facilities located in the South Satellite. However, a new International Arrivals Facility (IAF), to be located adjacent to Concourse A, is currently being designed and is planned to open by 2020.

3.2.1 Landside Passenger Terminal

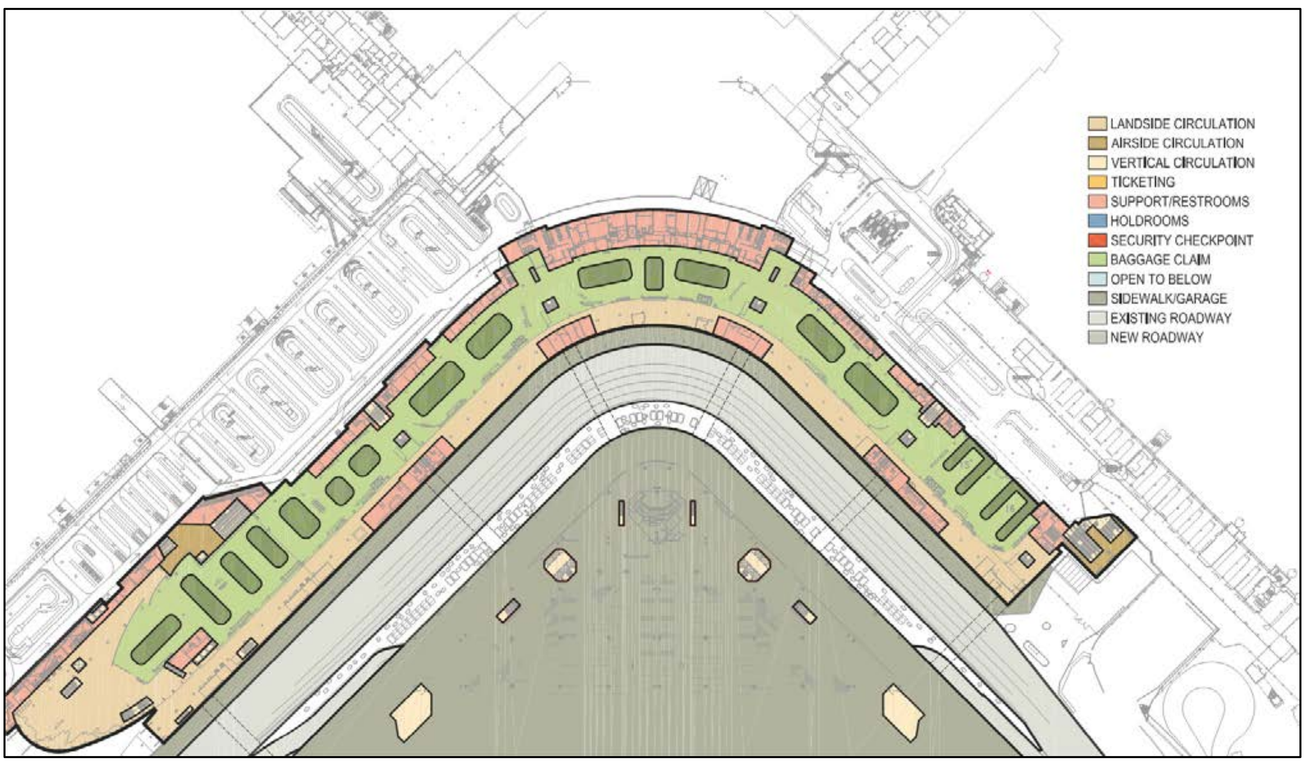
The existing passenger terminal consists of four public levels that are connected with a combination of elevators and escalators. The passenger terminal is connected to both the upper and lower curbsides by ramps and to the parking garage by multiple pedestrian bridges. The overall facility is in good condition and has been modified through a variety of Port and tenant improvements.

3.2.1.1 Arrivals Level

The arrivals level of the passenger terminal, shown on Figure 3-1, accommodates all international and domestic arriving passengers and includes seating areas and limited concessions. It is designed to allow passengers to locate and claim their checked baggage from numerous flat-plate and sloped-plate claim devices which are located around the public access portions of the arrivals level and immediately adjacent to the lower level curbside. Elevators and escalators are located in vertical cores throughout the arrivals level. These vertical cores are paired with ramps leading down to the lower level curbside.

The Gina Marie Lindsey Arrivals Hall is on the South end of the arrivals level and is planned to be connected to the new IAF. Vertical transportation cores lead to a mezzanine level, which is connected to the garage by pedestrian bridges and connected to the ticketing level.

Figure 3-1
Existing Arrivals Level Floor Plan
Seattle-Tacoma International Airport



Source: Port of Seattle, 2016.

The conclusions from our assessment of the arrivals level are:

- The arrivals level facilities do not provide the desired level of service to passengers and the public. This issue will be exacerbated as activity increases.
- The ramps leading to the lower level curbside reduce the amount of usable space on the arrivals level by forcing passenger circulation into the bag claim area. This limits the overall efficiency of the space, limits opportunities to expand, and degrades the level of service provided.
- Escalator cores encroach on the space and provide visual barriers between the bag claim areas.
- The capacity of the baggage claim devices (i.e., the length of the belts, also referred to as presentation length) and the surrounding claim areas is insufficient, resulting in crowding and below standard levels of service.

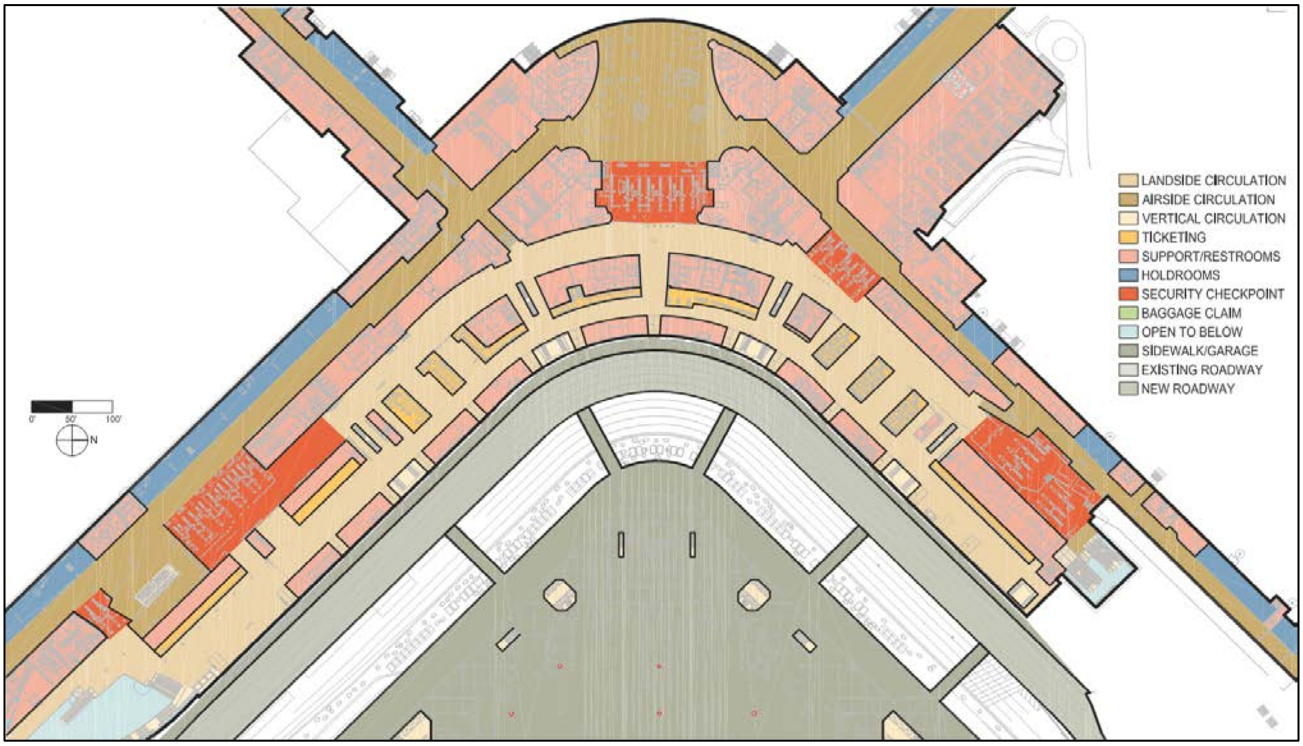
3.2.1.2. Ticketing Level

The ticketing level of the of the passenger terminal, shown on Figure 3-2 accommodates departing passenger check-in and baggage drop functions as well as airline ticketing offices, concessions, and security check points. Ticketing and bag drop counters are arranged in both the traditional in-line counter as well as in the back-to-back ticket island configurations. Ticketing and bag drop counters are located along the glass wall facing the upper level curbside and in the interior of the terminal. Circulation pathways are located both in front of and behind (where appropriate) the ticketing and bag drop counters.

Passenger Security Screening Checkpoints (SSCPs) are provided at four locations on this level within the north-south circulation pathway located behind the ticketing counters. The checkpoint sizes and queueing layouts vary, but are distributed to provide SSCP options closer to gates and existing Satellite Transit System (STS) stations as well the central concession node between concourses B and C. The queuing areas for the SSCPs 2 through 4 are so large that they severely restrict the north-south corridor designed to provide access to the SSCPs, food, beverages, and concessions.

Vertical transportation cores are positioned to align with bridges connecting the garage to the terminal. These cores, along with ramps up to the upper level curbside force the passenger circulation corridor further into the building. This results in underutilized space in some areas of the ticketing level and a severely restricted north-south circulation corridor in front of the check-in and bag drop counters.

Figure 3-2
Existing Ticketing Level Floor Plan
Seattle-Tacoma International Airport



Source: Port of Seattle.

The conclusions from the assessment of the ticketing level are:

- The ticketing level does not consistently provide the desired level of customer service.
- The ability to expand the SSCPs is currently limited by existing functions.
- SSCP queues currently encroach on passenger circulation areas behind the ticket counters to the extent that they severely restrict access to the SSCPs, food, beverages, and concessions.
- Ticketing functions are spread out and arrayed in multiple configurations and not as efficient as possible.
- Ramps from the upper level roadway and escalators from the mezzanine level below encroach on the ticketing level space and force passenger circulation further into the building. This results in underutilized space, the misalignment of passenger functions with passenger flows, and severely restricted passenger circulation paths.

The office mezzanine is located directly over the ticketing area and accommodates a variety of functions. These functions include Port and airline offices, USO facilities, conference rooms and badging offices. The mezzanine level extends from one end of the ticketing level to the other, ultimately connecting the Port of Seattle airport office tower to the terminal.

3.2.2 Airside Concourses and Satellites

3.2.2.1 Concourse A

Concourse A is the newest of the concourses and serves multiple airlines on 14 gates. Concourse A is single loaded (i.e., it accommodates aircraft gates on only one side), spacious, and designed to incorporate high ceilings and provide abundant natural lighting. Moreover, it provides a high level of customer service.

Concourse A could accommodate the expansion of hold rooms and the provision of additional concessions, if needed. There are plans to connect many of the Concourse A gates with the new IAF, which would allow even greater productivity and flexibility by allowing the gates to be used for either domestic or international arrivals. Access to the STS system is located adjacent to Gate A4.

The conclusions from the assessment of Concourse A are:

- The existing holdrooms are adequate and could be expanded if necessary.
- The distribution, density and quality of concessions should increase with the addition of international arrival and departure gates.
- The travel distance to and the size of existing toilet facilities appears to be adequate. As the size of aircraft during the peak hour increases there may be times when toilet facilities will become crowded.

3.2.2.2 Concourse B

Concourse B is one of the oldest concourses at the Airport. This concourse is double loaded (i.e., it accommodates aircraft gates on both sides) includes two level changes along its length, and accommodates 12 gates. Some holdrooms on Concourse B are undersized for the current fleet mix and are often crowded. Concessions are limited and, due to the narrow concourse width, restrooms are smaller than those on other concourses and passenger movement can feel constrained. Access to the STS system is at the end of the concourse near gate B11.

The conclusions from the assessment of Concourse B are:

- Existing holdrooms are undersized for the existing aircraft mix and passengers often stand in the circulation corridor.
- The concessions on Concourse B are limited in size and locations. Sizes are constrained due to the size of the concourse and locations are limited because of holdroom needs.
- The distance to toilet facilities is acceptable but the number of fixtures available is insufficient.

3.2.2.3 Concourse C

Concourse C, like Concourse B, is one of the oldest concourses in the Airport. Alaska Airlines is the primary air carrier operating out of Concourse C, which has sixteen holdrooms serving 20 aircraft parking positions (6 parking positions are equipped with passenger boarding bridges and 14 positions are ground loaded). The configurations of the hold rooms are purpose-built based on both the apron depth available for aircraft parking and the differences in the requirements between Alaska's mainline aircraft fleet and Alaska's regional aircraft fleet. Thus, the hold rooms for gates C2, C4, C6, C8, and C10 are relatively small, sized for regional aircraft (Alaska's regional aircraft are ground loaded; passengers move between the concourse and aircraft through covered walkways), whereas the hold rooms for gates C9, C11, C15, C17, C18, and C20 are relatively spacious, sized for mainline jets. Access to the STS system is at the end of Concourse C adjacent to gates C11 and C15.

The conclusions from the assessment of Concourse C are:

- The holdroom space appears adequate for the current aircraft accommodated.
- The food and beverage and retail facilities in Concourse C appear to be adequate.
- The locations and sizes of toilets appear to be adequate.

3.2.2.4 Concourse D

Concourse D is a single loaded concourse, is in good condition, and accommodates 10 gates. Five gates are grouped at the north end of the concourse with adjoined hold rooms.

The conclusions from the assessment of Concourse B are:

- The width of Concourse D is narrow and limits passenger movement.
- The existing holdrooms vary in size. The holdrooms at gates D1-D6 may experience some crowding but do not need to be enlarged. The holdrooms at Gates D6-D10 are spacious and permit holdroom sharing to avoid crowding at a single gate.
- There are few concessions available in Concourse D and their opportunity to expand is limited by the existing space.
- The number of toilets is inadequate for the activity being accommodated.

3.2.2.5 South Satellite

There are 14 holdrooms in operation at the South Satellite serving 15 aircraft parking positions. Currently all international arriving passengers are processed through Customs and Border Protection facilities located in the South Satellite, which is wide and has gates located along the exterior and concessions located in the interior. The only connection to the main terminal building is through the existing STS. There is a renovation project planned to expand the South Satellite and update its systems and finishes. This renovation project is being coordinated with a project to design and construct a new landside IAF, adjacent to Concourse A that will house new Customs and Border Protection facilities. Please refer to Section 3.4.5 for additional information.

The conclusions from the assessment of the South Satellite are:

- The holdrooms are currently adequate for the aircraft accommodated. As the number of widebody aircraft accommodated increases, the holdrooms will need to be modified accordingly.
- All concessions are currently located in a central food court and restaurant with some retail at the edges. The concessions space will be modified during the renovation project.
- Existing toilets meet the needs of the gates being served. Adjustments may be appropriate during the planned renovation project.

3.2.2.6 North Satellite

The NorthSTAR project, currently underway, will result in the expansion and total renovation of the North Satellite by 2020. The North Satellite currently has 14 gates; the NorthSTAR project will result in 20 gates. The only connection to the main terminal building is through the existing STS.

3.2.3 Satellite Transit System

The STS began operating in 1972 and was refurbished approximately 30 years later. The system consists of two loops and a shuttle system serving the existing concourses and satellites. The north loop serves Concourse C, Concourse D, and the North Satellite. The south loop serves Concourse A, Concourse B, and the South Satellite. The shuttle system, which operates between Concourse A and Concourse D, connects the north and south loops.

While the existing system adequately serves the current concourses, the addition of a significant number of new gates may result in the requirement for system modifications to maintain the current passenger minimum connect time (MCT) between international and domestic flights. Currently, MCT is 80 minutes. The existing system can continue to be utilized to serve all or a part of the existing concourses but another system or extension of the existing STS may ultimately be needed for new gates.

There are currently three routes that passengers need to take to transfer between the furthest gates. The locations of the existing station entrances are not intuitive to passengers emerging from security checkpoints. Additionally, the configuration of routes requires some passengers to transfer trains, which can be difficult for first-time passengers. These wayfinding issues increase the chance for passengers to miss their station stops, leading to increased travel time and overall lower perceived level of service. Adding a fourth or fifth system to the existing layout would potentially further compound these wayfinding issues and negatively impact passengers’ experience at the Airport. Mitigating wayfinding issues and effectively integrating existing and new systems will be key to providing the desired level of customer service.

3.2.4 U.S. Customs and Border Protection Facilities

The U.S. Customs and Border Protection (CBP) facilities at the Airport, located in the South Satellite and constructed in 1973, have reached capacity. Considerable planning has been completed and the Port Commission has directed that a new International Arrivals Facility (IAF), housing new CBP facilities, will be constructed as quickly as possible.

In parallel with the SAMP, IAF programming and planning were completed in August 2014. In September 2014, the Port's Program Management Group assumed responsibility for advanced planning and design of the IAF.

3.3 Desired Passenger Terminal Characteristics and Planning Assumptions

This section summarizes the desired passenger terminal characteristics that were considered and the assumptions that were made in preparing the passenger terminal requirements. The summary is organized by functional areas of the passenger terminal following a discussion of the level-of-service concept and passenger activity assumptions.

3.3.1 Level of Service

Level of service (LOS) standards used to determine terminal facility requirements for the SAMP are shown in Table 4-1. The LOS standards were adapted from a variety of sources including the Port of Seattle, airlines, consulting firms, Transportation Security Administration (TSA), U.S. Customs and Border Protection (CBP), International Air Transport Association (IATA), Airport Revenue News (ARN) benchmarking, Transportation Research Board (TRB), Highway Capacity Manual, TRB Airport Cooperative Research Program (ACRP)Reports, and the Official Airline Guide (OAG). LOS standards for existing "brownfield" terminals, like the Airport are often different than LOS standards used for planning new "greenfield" terminals due to existing constraints and cost.

Table 3-1
Level of Service Standards
Seattle-Tacoma International Airport

Functional Area	LOS Metric	LOS Source
Departure and Arrival Curb	Private vehicles park in 3 lanes maximum with 2 minute dwell max	Port of Seattle
	LOS C	TRB Highway Capacity Manual (6th Edition)
Check-In	Fit queue in designated area LOS Optimum	IATA Airport Development Reference Manual (10th Edition)
	Number of processors	Airlines
Security Screening Checkpoint	10 minute maximum wait in queue	TSA SSCP Staffing (Checkpoint Design Guide)
	Fit queue in designated area	Port of Seattle
Bag Screening	Calculated number of screening machines = N + 1	TSA Bag Screening (Planning Guidelines & Design Standards for Checked Bag Inspection Systems)
Bag make-up	Number of staged make-up cart positions by aircraft type	IATA Airport Development Reference Manual (10th Edition)
Bag claim	• Percentage of passengers claiming bags • Linear feet of device • Device utilization time	IATA Airport Development Reference Manual (10th Edition)
Concessions	Sales per enplaning passengers sales per square foot	ARN Annual Factbook
Restrooms	Number of fixtures	TRB ACRP Report 130 (Guidebook for Airport Terminal Restroom Planning & Design)
	• Number of fixtures • Distance to restrooms	Washington State Building Code
Holdroom	Seated and standing passengers	IATA Airport Development Reference Manual (10th Edition)
	Seated and standing passengers	Airlines
Minimum Connect Time	90 minutes for international to domestic transfers	Port of Seattle
Gates	• Time on gate before towing • buffer time between flights • annual preferential gate allocation • minimum connect time	Port of Seattle
FIS	• Guidelines for functional area • Automated primary	CBP Airport Technical Design Standards (2016)
	• Baggage claim • Gates • Minimum connect time	Port of Seattle

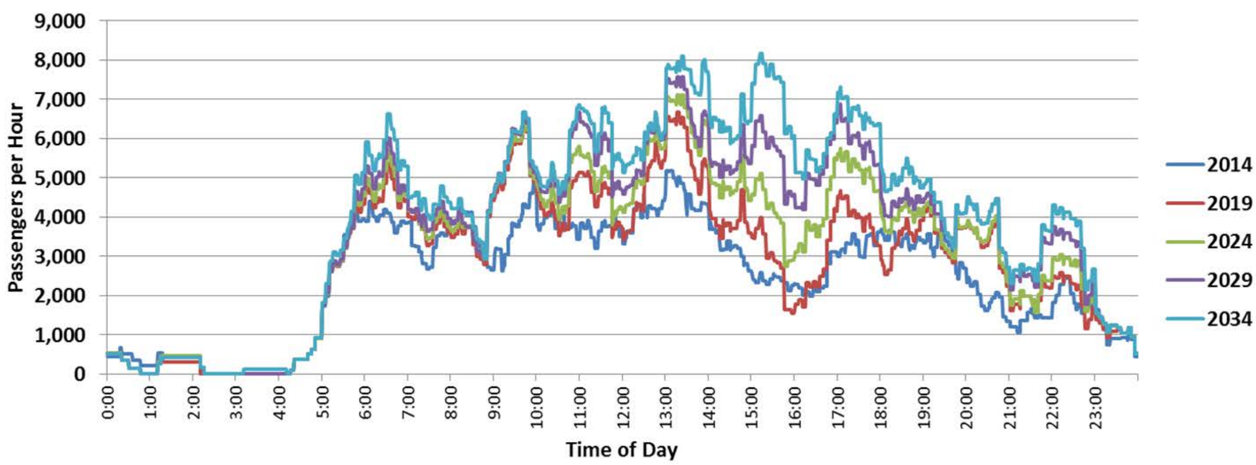
LOS = Level-of-Service

Source: Port of Seattle, 2015.

3.3.2 *Passenger Activity Assumptions*

Estimates of passenger activity necessary to develop passenger facility requirements for PALs 1 through 4 (2019, 2024, 2029, and 2034, respectively) were obtained from the design day flight schedules. The development of design day flight schedules is described in Appendix 1 of this technical memorandum. The pattern of hourly passenger activity reflected in the design day flight schedules is illustrated in Figure 3-3 for departing passengers.

Figure 3-3
Projected Hourly Flows of Departing Passengers
Seattle-Tacoma International Airport



Source: LeighFisher, 2016.

3.3.3 *Airline Check-In and Bag Drop*

Check-in and bag drop processes are typically sized to accommodate peak hour passenger traffic demand. Each airline will structure its operations and facilities to best suit the needs of its passengers. The Airport currently allows tenant airlines to operate ticketing and bag drop counters in multiple configurations which include in-line ticket counters as well as island counter arrangements. While counters are aligned differently in various sections of the ticketing hall, each airline provides a different service such as kiosk boarding passes; self-tagging of baggage; home tagging of baggage; priority / full service counters and baggage drop areas. Technology is changing the way passengers interact with airline personnel and fulfill their ticketing needs. Often technology allows the airlines to process more people through the same facility footprint without expansion.

Passenger check-in at the Airport also occurs at Common Use Self Service (CUSS) kiosks located both in the garage and in the terminal building. This allows passengers to skip crowded lines and proceed directly to the security screening checkpoint.

Requirements were estimated assuming common use systems, as appropriate, the maximum reasonable benefits from technology, and IATA's Optimum LOS.

3.3.4 Passenger Security Screening

Walk distance from ticketing and bag drop to departure gates and STS stations is an important consideration in planning SSCP locations. Other considerations include (1) the flexibility to shift SSCP lane designations, for example among TSA PreCheck, premium passengers, standard passengers, and Clear, and (2) providing additional crew and employee lanes as peak period passenger demand increases. Centralizing SSCP functions can help increase workforce productivity and flexibility in assigning screening lanes.

Requirements were estimated assuming the maximum reasonable benefits from technology and IATA's Optimum LOS.

3.3.5 Holdrooms

Gate holdrooms are typically sized to accommodate the largest aircraft planned for individual gates and deplaning and boarding functions. Holdrooms should be planned with the flexibility to (1) accommodate variations among the airlines related to passenger processing and holdroom configuration, (2) permit holdroom sharing among gates, and (3) accommodate the blending of holdroom space with concessions space.

Our assessment of existing holdroom sizes were summarized, by concourse and satellite, in Section 3.2.2. Given the Port's priorities for SAMP and its current plans that will result in significant changes and improvements to holdrooms (i.e., NorthSTAR, which will result in a virtually all-new North Satellite and the plan to renovate the South Satellite), we did not estimate requirements for existing hold rooms. Instead, we focused on requirements for new holdrooms associated with new gates. The approach used to ensure the adequacy of new holdrooms was to ensure appropriate widths for all new concourses associated with new holdrooms. This concept is further explained in Technical Memorandum No. 6 – Alternatives.

3.3.6 Gates

Given the severe shortage of land at the Airport, the driving principle in gate planning was to plan gates to ensure maximum flexibility and the maximum potential for high utilization and productivity. Thus, (1) aircraft gates will be planned with the flexibility to accommodate a range of aircraft, consistent with the length and depth of the aircraft apron and the requirements of the airlines using the gates, and (2) gates will be shared among airlines, where possible.

3.3.7 Concessions

Concessions are important Airport revenue generators as well as key factors in assuring customer satisfaction. The Port has both a comprehensive program and a specialty consultant to ensure the continued delivery of high-quality concessions. The approach taken during SAMP planning was to (1) assume the Port and its specialty consultant are continuously reviewing concessions requirements for existing space, and (2) ensure the new facilities planned as part of the SAMP allow space that is appropriate for concessions given the Port's objectives. The allocation of that space retail, food and beverage concessionaires will occur during advanced planning and design, following the completion of the SAMP.

3.3.8 Public Toilets

Public toilets should be placed in locations that not only satisfy code requirements, but also the Port Commission's level of service objectives. The approach taken in developing the SAMP was to identify existing deficiencies, and plan new spaces with sufficient areas to satisfy those requirements and meet those objectives. The allocation of the planned space and design of the facilities will occur during advanced planning and design, following the completion of the SAMP.

3.3.9 Baggage Handling Systems

Baggage handling systems (BHS) are complex, expensive, and require considerable space. Given the technical complexities of BHS, the Port has engaged a BHS designer who is responsible for the concepts and systems related to baggage screening, early baggage storage, and a baggage conveyor "backbone" are being planned; collectively, these systems will be incorporated into a project referred to as the Baggage Optimization Project. The planning team has coordinated with the BHS designer. However, final decisions governing the overall BHS design have not been made and will occur during detailed planning and design that will occur following completion of the SAMP.

The concepts governing the BHS design are associated with the processing of outbound and inbound baggage. Outbound baggage enters the system at a bag drop facility from which it is transported, in sequence, to one of four locations: (1) baggage security screening, (2) early baggage storage (if provided), (3) outbound baggage make-up where baggage is sorted and placed into containers or carts, and (4) departing aircraft. Upon removal from arriving aircraft, inbound baggage is transported, typically by tug and cart, to inbound baggage belts (where the baggage is unloaded onto inbound baggage systems, and then to claim devices where baggage is claimed by arriving passengers.

Given the responsibilities of the BHS designer, SAMP BHS planning focused on requirements for outbound makeup areas, inbound claim devices, and domestic baggage claim.

3.3.10 Automated People Mover (APM)

APMs have been used in airports for over forty years to connect passengers to airport activity centers, such as the terminals and concourses, transit, remote parking, and rental car facilities. The use of APMs reduces walk distances, decreases travel time, improves levels of service, and obviates the need for buses that contribute to roadway congestion in some cases.

The distance between the new IAF located at Concourse A and new domestic gates (locations to be determined during the alternatives task) may create challenges for passengers connecting from arriving international flights to departing domestic flights. In order to deliver these passengers with a high level of service, the chosen system(s) should be able to provide a minimum connect time of 80 minutes. This high level of connecting service should be achievable across all gates, regardless of their locations. The APM also should provide high levels of service for passengers connecting between domestic flights.

The objective is to effectively integrate the existing STS and planned systems to simplify the inter-Airport transportation experience.

3.3.11 U.S. Customs and Border Protection Facilities

As stated in Section 3.2.4, the Port intends to construct a new IAF that will house new U.S. CBP facilities. The key characteristics and planning assumptions related to the new IAF, scheduled to open in the fourth quarter of 2019, include the following:

- The IAF will be a new multi-level, 450,000-square-foot facility located east of the current concourse A.
- An iconic aerial walkway, which will span 900 linear feet at a clear height of 85 feet over the existing taxi lane, will connect arriving international passengers from the South Satellite across the top of Concourse A to the new IAF.
- Creation of a secure international corridor on Concourse A will mean more gates for arriving international flights with a direct connection to the IAF.

3.4 Passenger Terminal Facility Requirements

This section presents the requirements for those terminal functions that will most influence the development of terminal alternatives. The requirements for those functions are presented in Table 3-2; the approaches and key assumptions in their estimation are described in the following paragraphs.

3.4.1 Gates

The number of gates and remote aircraft parking positions required to accommodate activity in the planning day flight schedules for PALS 1, 2, 3, and 4 (2019, 2024, 2029, and 2034, respectively) was estimated using LeighFisher's Gate Model.

3.4.1.1 Background and Approach

The term "gate" refers to an aircraft parking position used to enplane passengers from or deplane passengers to a passenger terminal concourse or satellite. Passengers transition between aircraft gates and a passenger terminal concourse or satellite via either an enclosed passenger boarding bridge (a gate so equipped is referred to as a "contact" gate) or on a designated path, outside the terminal concourse or satellite, located on the aircraft parking apron (a gate so equipped is referred to as a "ground-loaded" gate). Larger mainline jet aircraft are typically accommodated at contact gates whereas smaller regional jet aircraft are frequently accommodated at ground-loaded gates.

A “remote” aircraft parking position is typically located away from, but relatively near to contact gates and ground loaded gates and is also referred to as a hardstand or remain overnight aircraft parking position.

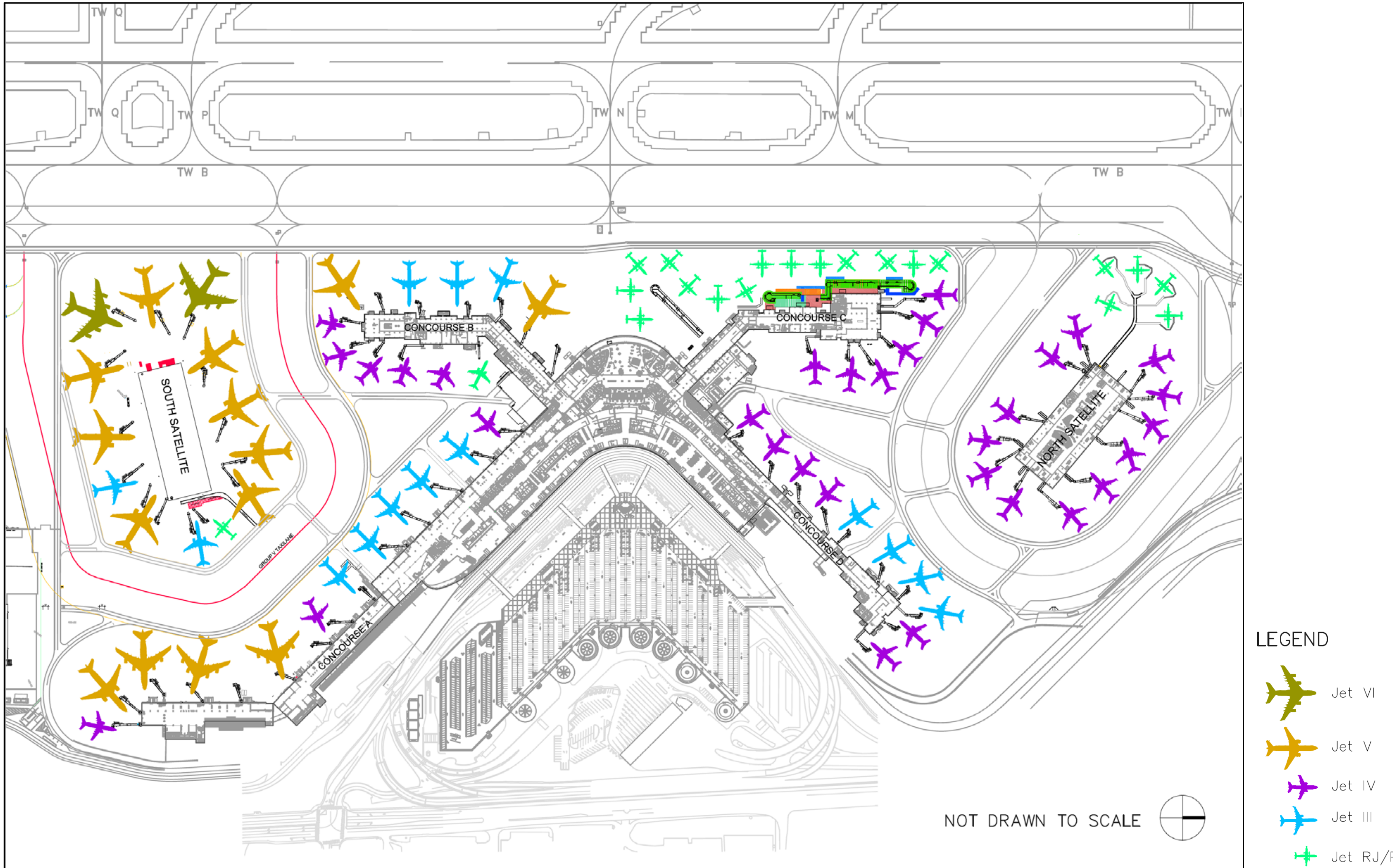
Figure 3-4 illustrates the aircraft parking ability of the Airport’s gates as configured in June 2015, when accommodating the maximum mix (i.e., number) of wide body aircraft.

Table 3-2
Summary of Major Terminal Facilities Requirements
Seattle-Tacoma International Airport

	Existing 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Gates					
International	13	18	22	24	29
Domestic	70	77	82	82	84
Total	83	95	104	106	113
Off-gate parking positions		28	31	37	44
Check-In & bag drop					
Kiosk w/o bag check	40	77	80	84	90
Agent with bag check	214	211	219	235	250
Garage kiosk	15	11	11	11	12
Curb kiosk	15	14	15	16	17
Total	284	313	325	346	369
Passenger security screening checkpoint					
Number of screening lanes	31	34	36	37	41
Queue Length (ft.; max 10 min wait)	n/a	992	1,050	1,079	1,196
Outbound baggage system					
Peak hour bags	3,564	4,748	5,911	7,444	8,135
Security screening machines	12	9	11	15	16
Make-up devices	n/a	490	386	422	464
Early-bag storage positions	0	n/a	393	652	715
Domestic baggage claim					
Claim frontage (ft.)	2,700	2,982	3,441	4,136	4,453
Claim devices	16	18	20	22	24

Sources: Requirements for gates and security screening checkpoints estimated by LeighFisher, June 2015; requirements for outbound baggage systems and domestic baggage claim estimated by Logplan, December 2016.

Figure 3-4
Illustration of Aircraft Parking Capability of Existing Gates Assuming Maximum Widebody Aircraft
Seattle-Tacoma International Airport



Source: Port of Seattle, June 2015.

Inputs to LeighFisher's gate model included:

- **Design day flight schedules.** A flight schedule was developed for each PAL and included aircraft type, arrival time, and departure time for each flight. The development of design day flight schedules is described in Appendix 1 of this Technical Memorandum No. 5. The schedules are available in an Excel file from the Port of Seattle Aviation Planning Department.

- **Design day flight schedules**. A flight schedule was developed for each PAL and included aircraft type, arrival time, and departure time for each flight. The development of design day flight schedules is described in Appendix 1 of this Technical Memorandum No. 5. The schedules are available in an Excel file from the Port of Seattle Aviation Planning Department.

- **Minimum arrival and departure times**. Minimum arrival and departure times represent the minimum times a flight must occupy a gate to complete an arrival or departure operation, respectively. The assumed minimum arrival and departure times are shown in Table B-1 of Appendix B of this Technical Memorandum No. 5. .

- **Earliness and lateness buffers**. Buffers allow for schedule variability by reserving blocks of gate time for flights that may be early or late relative to schedule. In the Gate Model all flights are assumed to arrive and depart on schedule. These buffers provide a time "cushion" between successive gate operations. The earliness and lateness buffers used for international flights were derived by analyzing historic operations data for SEA and represent the 85th percentile values for arrival time variance (i.e., 85 percent of the time the flight arrives within the span of time given by: [Scheduled Arrival Time -Earliness Buffer] + [Scheduled Arrival Time + Lateness Buffer]). The earliness and lateness buffers assumed are shown in Table B-2 of Appendix B of this Technical Memorandum No. 5.

- **Maneuver buffers**. Maneuver buffers are the amount of time required between scheduled gate activity to permit aircraft and equipment to be clear of the gate (i.e., the gate model applies a maneuver buffer following each scheduled departure). Maneuver buffer are also shown in Table 2 of Appendix 2 of this Technical Memorandum No. 5.

- **Minimum Turn Times**. Minimum turn times are the minimum time on gate to turn an aircraft, i.e., the minimum time to unload arriving passengers, exchange baggage, refuel, cater, and load departing passengers in quick succession. Minimum turn times input to the Gate Model are the sum of the minimum arrival and departure times shown in Table 1 in Appendix 2 of this Technical Memorandum No. 5. In the Gate Model, aircraft with scheduled ground times less than or equal to the minimum turn time had a full lateness buffer applied after the scheduled departure time. Aircraft with scheduled ground times greater than the minimum turn time had either a shortened lateness buffer or no lateness buffer applied depending on how much "slack" was available in in their scheduled ground time.

- **Aircraft towing rules**. Aircraft towing rules define when towing occurs between gates and remote aircraft parking positions and how much time is required. The Gate Model permits aircraft with scheduled ground times significantly greater than the sum of the minimum arrival and minimum departure times to be towed and parked remotely in order to make gates available to accommodate other flights. "Significantly greater" is defined as 45 minutes. All aircraft towing operations to move an idle aircraft to a remote parking position or another gate were allotted 15 minutes. Similarly, an aircraft towing operation from a remote parking position to an active gate for departure is also allotted 15 minutes.

- **Gate sharing rules**. Gate sharing rules define how gate resources may be shared among airlines (sharing was always permitted within the groups of activity for which gate requirements were estimated and sharing between groups was permitted on an exception basis). The groups of activity for which requirements were estimated are defined in the following Section 3.4.1.2.

3.4.1.2 Requirements

Gate requirements were estimated for four groups of activity:

- **International gates**. This group was appropriate because of the need for each international gate to be connected to the International Arrivals Facility by a sterile corridor and the need to prioritize international gate use for international arrivals.

- **Delta Air Lines domestic gates**. This group was appropriate because of Delta's increasing volume of activity on the south half of the Airport and the relationship of its domestic network to its growing international hub.

- **Alaska Air Group gates**. This group was appropriate because of the Group's market share at the Airport (greater than 50%) and dominant position.

- **Other domestic gates**. This group was a logical consequence of the three primary groups.

The requirements for remote aircraft parking positions (i.e., additional off-gate positions for remain overnight aircraft) were estimated for two groups of activity—International and Delta domestic, and other domestic—reflecting a potential split between requirements for the south and north Airport.

The aircraft parking capability of the Airport's gates as of June 2015 is illustrated on Figure 3-4 assuming a maximum wide-body aircraft mix; the Airport's gate inventory as of June 2015 is shown in Table 3-3. Gate requirements are summarized in Table 3-2 and Tables 3-3 through 3-7. Tables 3-4 through 3-7 summarize the Airport's gate and remote aircraft parking requirements for PAL 1 (2019), PAL 2 (2024), PAL 3 (2029), and PAL 4 (2034), respectively.

Gate and remote aircraft parking requirements are displayed graphically in "ramp charts" (i.e., Gantt charts) produced by the gate model and included in Appendix 2. The ramp charts are also available in an Excel file from the Port of Seattle Aviation Planning Department. Although gate requirements were estimated for both Delta Air Lines and the Alaska Air Group, a non-disclosure agreement between the Port and Delta prevents the public disclosure of information specific to Delta. Accordingly, the gate requirements information presented in this Technical Memorandum has been aggregated into two categories—international and domestic.

Table 3-3
Existing Aircraft Gate Inventory
Seattle-Tacoma International Airport

	Maximum Narrow Body Mix *(a)*						Maximum Wide Body Mix *(a)*					
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
Gates												
International	1	1	6	5	2	15	1	--	2	8	2	13
Domestic	26	31	18	2	--	77	20	32	12	6	--	70
Total gates	27	32	24	7	2	92	21	32	14	14	2	83

(a) The number of aircraft parking positions that can be simultaneously occupied on a given ramp area varies based on configuration and layout. Flexibly configured aprons can accommodate various discrete combinations of small and large aircraft. The narrow body mix presents the upper bound of the number of aircraft that can be accommodated assuming the smallest aircraft size and the wide body mix presents the lower bound assuming the largest aircraft size.

The column headings refer to the maximum aircraft size accommodated at the gates.

RJ/TP = a gate capable of accommodating aircraft no larger than a regional jet or turbo prop aircraft
Jet III = a gate capable of accommodating aircraft no larger than airplane design group III
(i.e., wingspans less than 118 feet)
Jet IV= a gate capable of accommodating aircraft no larger than airplane design group III
(i.e., wingspans less than 171 feet)
Jet V = a gate capable of accommodating aircraft no larger than airplane design group III
(i.e., wingspans less than 214 feet)
Jet VI = a gate capable of accommodating aircraft no larger than airplane design group III
(i.e., wingspans less than 262 feet)

Source: LeighFisher, 2015.

Table 3-4
Existing Gate and Off-Gate Aircraft Parking Requirements – PAL 1 (2019)
Seattle-Tacoma International Airport

	Aircraft size *(a)*					
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
Gates						
International	--	--	2	16	--	18
Domestic	19	47	10	1		77
Total gate requirement	19	47	12	17		95
Off-gate parking						
Total demand	6	31	5	4		46
Demand accommodated at gates *(b)*	5	11	2	--		18
Off-gate parking requirement	1	20	3	4		28

(a) The column headings refer to the maximum aircraft size accommodated at the gates.
RJ/TP = a gate capable of accommodating aircraft no larger than a regional jet or turbo prop aircraft
Jet III = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 118 feet)
Jet IV= a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 171 feet)
Jet V = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 214 feet)
Jet VI = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 262 feet)

(b) Off-gate parking demand that could be accommodated on available gates was determined by visual inspection of Gate Model ramp charts.

Notes:
Gate and off-gate parking requirements shown are based on the corresponding ramp chart, located in Appendix 2, and assume a maximum wide body configuration.

Source: LeighFisher, 2015.

Table 3-5
Existing Gate and Off-Gate Aircraft Parking Requirements – PAL 2 (2024)
Seattle-Tacoma International Airport

	Aircraft size *(a)*					
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
Gates *(a)*						
International	--	1	2	19	--	22
Domestic	21	50	10	1	--	82
Total gate requirement	21	51	12	20	--	104
Off-gate parking						
Total demand	7	38	4	3	--	52
Demand accommodated at gates *(b)*	5	16	-	-	--	21
Off-gate parking requirement	2	22	4	3	-	31

(a) The column headings refer to the maximum aircraft size accommodated at the gates.
RJ/TP = a gate capable of accommodating aircraft no larger than a regional jet or turbo prop aircraft
Jet III = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 118 feet)
Jet IV= a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 171 feet)
Jet V = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 214 feet)
Jet VI = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 262 feet)

(b) Off-gate parking demand that could be accommodated on available gates was determined by visual inspection of Gate Model ramp charts.

Notes:
Gate and off-gate parking requirements shown are based on the corresponding ramp chart, located in Appendix 2, and assume a maximum wide body configuration.

Source: LeighFisher, 2015.

Table 3-6
Existing Gate and Off-Gate Aircraft Parking Requirements – PAL 3 (2029)
Seattle-Tacoma International Airport

	Aircraft size *(a)*					
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
Gates *(a)*						
International	--	--	2	22	--	24
Domestic	21	51	8	2	--	82
Total gate requirement	21	51	10	24	--	106
Off-gate parking						
Total demand	7	42	6	4	--	59
Demand accommodated at gates *(b)*	4	15	3	--	--	22
Off-gate parking requirement	3	27	3	4	--	37

(a) The column headings refer to the maximum aircraft size accommodated at the gates.
RJ/TP = a gate capable of accommodating aircraft no larger than a regional jet or turbo prop aircraft
Jet III = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 118 feet)
Jet IV= a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 171 feet)
Jet V = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 214 feet)
Jet VI = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 262 feet)

(b) Off-gate parking demand that could be accommodated on available gates was determined by visual inspection of Gate Model ramp charts.

Notes:
Gate and off-gate parking requirements shown are based on the corresponding ramp chart, located in Appendix 2, and assume a maximum wide body configuration.

Source: LeighFisher, 2015.

Table 3-7

Existing Gate and Off-Gate Aircraft Parking Requirements – PAL 4 (2034)

Seattle-Tacoma International Airport

	Aircraft size *(a)*					
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
Gates *(a)*						
International	--	2	--	27	--	29
Domestic	12	63	6	3	--	84
Total gate requirement	12	65	6	30	--	113
Off-gate parking						
Total demand	7	47	5	7	--	66
Demand accommodated at gates*(b)*	3	17	2	-	--	22
Off-gate parking requirement	4	30	3	7	--	44

(a) The column headings refer to the maximum aircraft size accommodated at the gates.
RJ/TP = a gate capable of accommodating aircraft no larger than a regional jet or turbo prop aircraft
Jet III = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 118 feet)
Jet IV= a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 171 feet)
Jet V = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 214 feet)
Jet VI = a gate capable of accommodating aircraft no larger than airplane design group III (i.e., wingspans less than 262 feet)

(b) Off-gate parking demand that could be accommodated on available gates was determined by visual inspection of Gate Model ramp charts.

Notes:
Gate and off-gate parking requirements shown are based on the corresponding ramp chart, located in Appendix 2, and assume a maximum wide body configuration.

Source: LeighFisher, 2015.

3.4.2 Airline Check-in and Baggage Drop

Requirements were developed using spreadsheet models, anticipated peak-period passenger activity for each airline at each PAL, and appropriate allowances for technology and process change. The requirements are shown in Table 4-2. Key observations from the requirements analyses were (1) the need for kiosks without bag check will increase rapidly, and (2) the need for additional agent positions with bag drop will not increase significantly until PAL 3.

3.4.3 Passenger Security Screening

Requirements for security screening checkpoint lanes were developed using spreadsheet models, anticipated peak-period passenger activity for each airline at each PAL, anticipated processing rates and lane types (i.e., TSA PreCheck, premium passengers, and general passengers), and reasonable expectations related to technology and process change. Aside from unforeseen and significant changes in security screening objectives, the requirement for the number of screening lanes and queue length is expected to steadily increase as activity increases. The requirements, shown in Table 3-2, assume a single checkpoint location and could increase depending on the alternative considered (e.g., the number of checkpoint locations).

3.4.4 Baggage Handling Systems

Baggage handling systems requirements were estimated using spreadsheet-based tools, planning assumptions and parameters based on Airport-specific data, design-day flight schedules for PAL 1 through PAL 4, and appropriate allowances for technology and process change. BHS requirements were developed for domestic and international outbound baggage makeup, inbound baggage handling, and domestic claim facilities. International claim requirements are included in the ongoing IAF design program.

3.4.4.1 Domestic and International Outbound Baggage Makeup

For the purposes of the SAMP, we assumed that additional outbound makeup space and devices will be provided where future facility expansion allows. The approach is to provide carousels capable of providing outbound makeup for more than one gate per device. It is important to recognize that baggage processing rates could be affected by the use of one or two baggage screening systems as well as the introduction of an Early Bag Storage (EBS) system. For the purposes of estimating requirements, we assumed an EBS system will be in place and operating by 2019.

The requirements for domestic and international outbound baggage handling systems are shown in Table 3-2.

3.4.4.2 Inbound Baggage Handling

The future concept of operation within the existing passenger terminal is to tug inbound baggage where it makes sense. If situations were to exist where gates are too far from bag claim devices for tugging to be practical, then high speed individual carrier systems (ICS) might be considered.

The difficulty is planning for more conventional methods regarding inbound baggage. There is very little space available for baggage sortation systems within the existing passenger terminal. The space that is available is occupied by outbound systems or essential functions. As additional baggage claim devices are added to meet claim requirements, additional claim feed belts will need to be added as well.

3.4.4.3 Domestic Baggage Claim

Recommended presentation lengths for the domestic baggage claim devices and the number of devices were developed based on the design day flight schedules and passenger profile metrics for the Airport. These passenger metrics include: originating and departing percentages; and the percentage of arriving passengers claiming a bag.

The requirements for domestic baggage claim are shown in Table 3-2.

3.4.5 U.S. Customs and Border Protection Facilities

The new IAF, scheduled to open in the fourth quarter of 2019, is currently being designed. Therefore, the SAMP did not include estimates of requirements for the IAF. However, the new IAF is being designed to:

- Increase passenger processing capacity by more than double to 2,600 passengers per hour (currently the Airport experiences daily peak passenger levels averaging over 2,000 passengers per hour for a facility designed for only 1,200 per hour).
- Nearly double the number of existing gates capable of serving international wide-body aircraft from 12 to 20 gates.
- More than double Passport Check booths and kiosks (from 30 to 80 booths).
- Increase the size and number of bag claim carousels from four to seven.
- Create a single bag claim process, eliminating the need for international passengers to ride a train to baggage claim.
- Create direct access from the IAF to ground transportation located at the Airport drives or garage.
- Reduce minimum passenger connection time to 75 minutes

Ground Access and Parking

This chapter presents assessments of existing ground access and parking facilities and summarizes the requirements that must be satisfied to accommodate the aviation activity forecast through the 20-year planning period.

4.1 Introduction

The chapter presents the requirements for meeting forecast ground transportation and parking demand for PALs 1 through 4 (i.e., 2019, 2024, 2029, and 2034, respectively) and the associated peak hour activity.

4.2 Existing Facilities and Operations

The Airport's ground access and parking facilities include off-Airport access roadways, on-Airport access roadways, terminal-area circulation roadways, curbside roadways, commercial vehicle facilities, public transit facilities, public parking, employee parking, rental car facilities, and pedestrian and bicycle facilities.

4.2.1 Off-Airport Access Roadways

Off-Airport roads of particular importance for the Airport include the surrounding state and regional highway network (i.e., I-5, I-405, SR 518, and SR 509) as well as local roadways (i.e., SR 99 / International Boulevard, S. 188th St, S. 170th St, and S. 160th St) that provide access to and from the Airport. Although the Port does not control these off-Airport access roadways, and their future requirements are outside the scope of the SAMP, the roads were evaluated by Port staff using the Sea-Tac airport travel demand forecasting model (the model). This model directly ties in the Puget Sound Regional Council (PSRC) land use, employment, trip generation, and travel patterns from areas outside the Airport and is integrated with data related to air passenger travel for the Airport. The model is based on year 2010 and reflects conditions during a peak hour in the afternoon (the peak period for regional traffic in the vicinity of the Airport). The model was used to develop volume forecasts for the peak hour and does not directly indicate LOS associated with these volumes. The performance of the roads was assessed using the volume/capacity ratio (V/C). Breakdown (or LOS F) occurs when the V/C ratio exceeds 1.0. Operations immediately downstream may reflect LOS E conditions.

Figures 4-1 and 4-2 depict key results of the 2010 model. Figure 4-1 depicts Airport versus non-Airport traffic volumes on roadways in and around the Airport. As shown, on-Airport and on SR 518 (between the Airport and I-5) the Airport contributes a significant share of the total traffic during the peak hour. On I-5, SR 509, and International Blvd., however, the Airport contributes a very small share of the total volume. Figure 4-1 also indicates that a high share of Airport traffic (87%) enters the Airport from the north via the North Airport Expressway while the remainder (13%) enters from the south via City of SeaTac streets. However, approximately 74% of Airport traffic is generated from areas north of the Airport. This discrepancy reflects that a high share of traffic generated to the south uses I-5 and SR 518 to travel to the Airport and therefore, enters Airport property from the north.

Figure 4-2 depicts the model's V/C ratios for 2010. As shown, in 2010 most off- Airport roads near the Airport had a V/C ratio of less than 1. Key regional access routes to and from the Airport, such as the I-5/I-405 interchange, I-405, and southbound I-5 (south of the Airport), had V/C ratios exceeding 1. According to Port staff, even though eastbound SR 518 had available capacity in the afternoon, congestion at the I-5/I-405 interchange caused traffic to back up along SR 518.

Other conclusions, based on assessing model results, are that congestion from on-Airport roadways occasionally reaches the SR 518 corridor, creating turbulence on westbound SR 518.

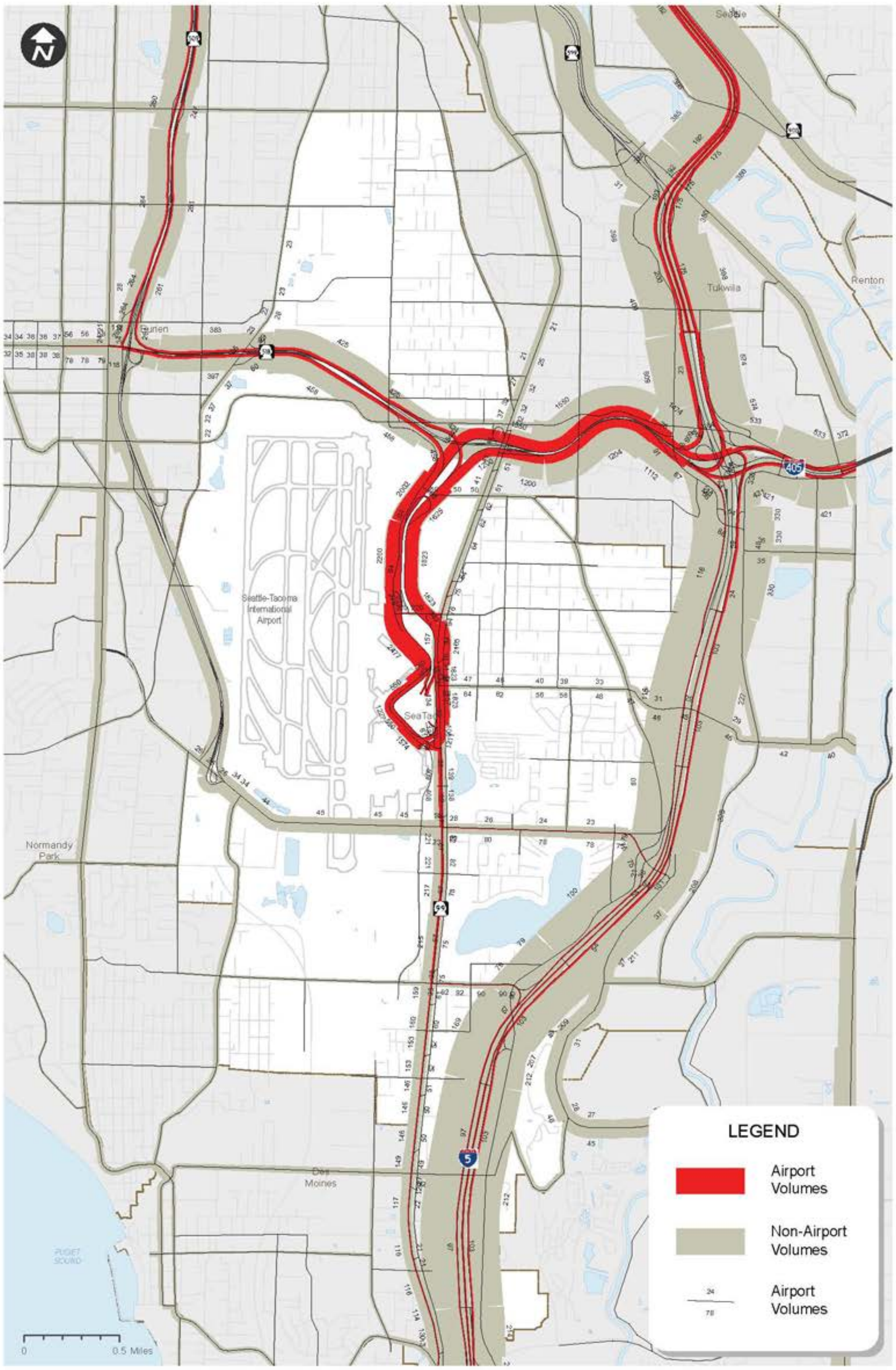
4.2.2 On-Airport Access Roadways

Figure 5-3 depicts key on-Airport access roadways (including ramps connecting to SR 518 which, while outside of Airport property, are used almost exclusively by Airport-related traffic). Peak hour 2010 volumes, as identified by the regional model, are provided in Table 4-1. As described in Section 4.2.1, approximately 87% of peak hour Airport traffic accesses the Airport to and from the north via the North Airport Expressway. The remaining volumes enter via the intersection at South 182nd St. and International Blvd. and via ramps connecting South 170th Street and the North Airport Expressway. As shown in Table 4-1, volume/capacity ratios on these roadways are generally 0.6 or lower during the regional peak hour. However, key access roadways, such as the southbound North Airport Expressway, experience congestion due to deficiencies on terminal-area roadways (described in Section 4.2.3), which cause traffic to back up onto access roadways.

Figure 4-1

Regional Travel Model Airport and Non-Airport Peak Hour Traffic Volumes - 2010

Seattle-Tacoma International Airport



Total Volumes - 2010 Existing

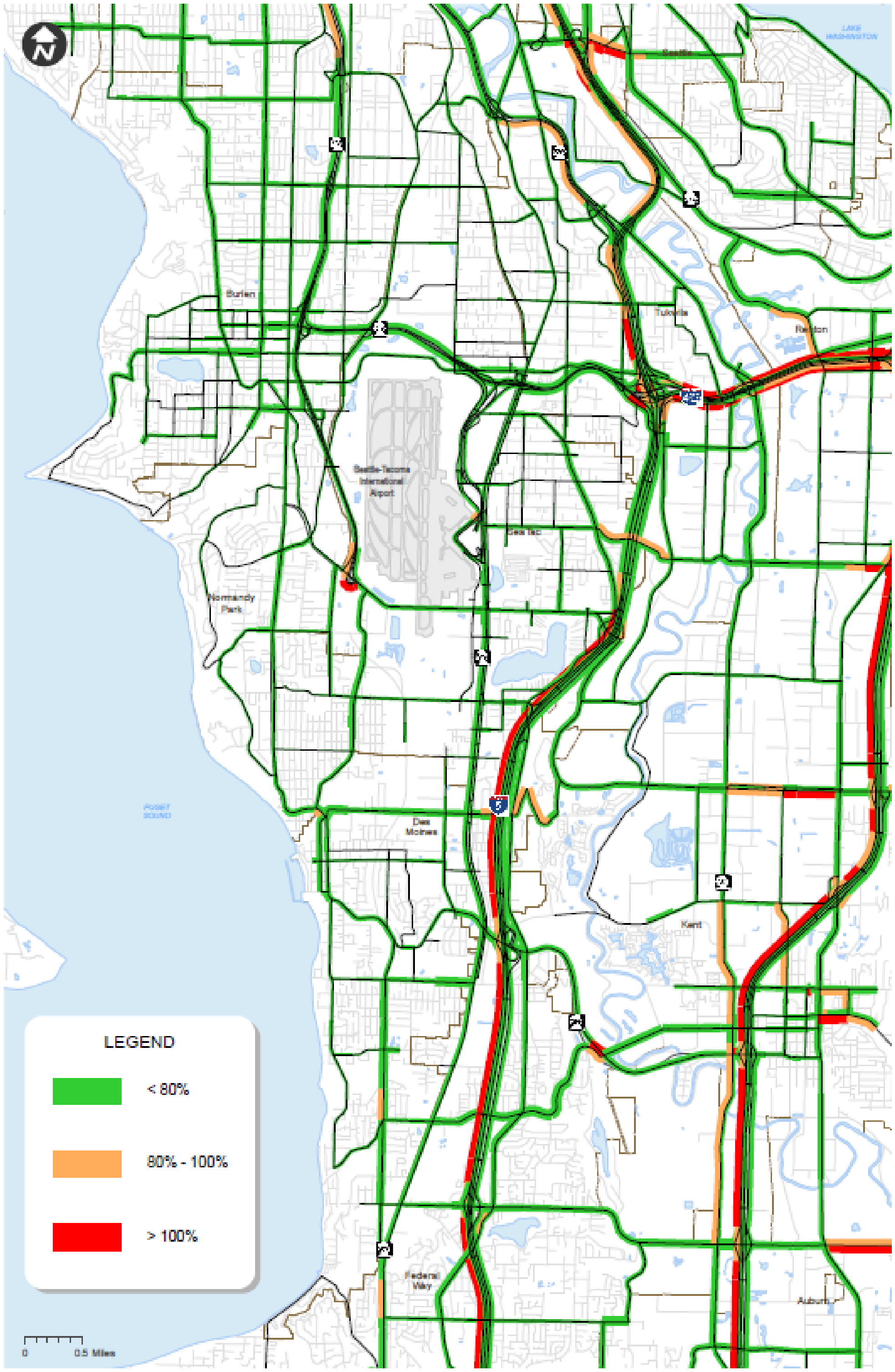
DRAFT FIGURE

Source: Port of Seattle, 2017.

Figure 4-2

Regional Travel Model Volume/Capacity Ratios - 2010

Seattle-Tacoma International Airport

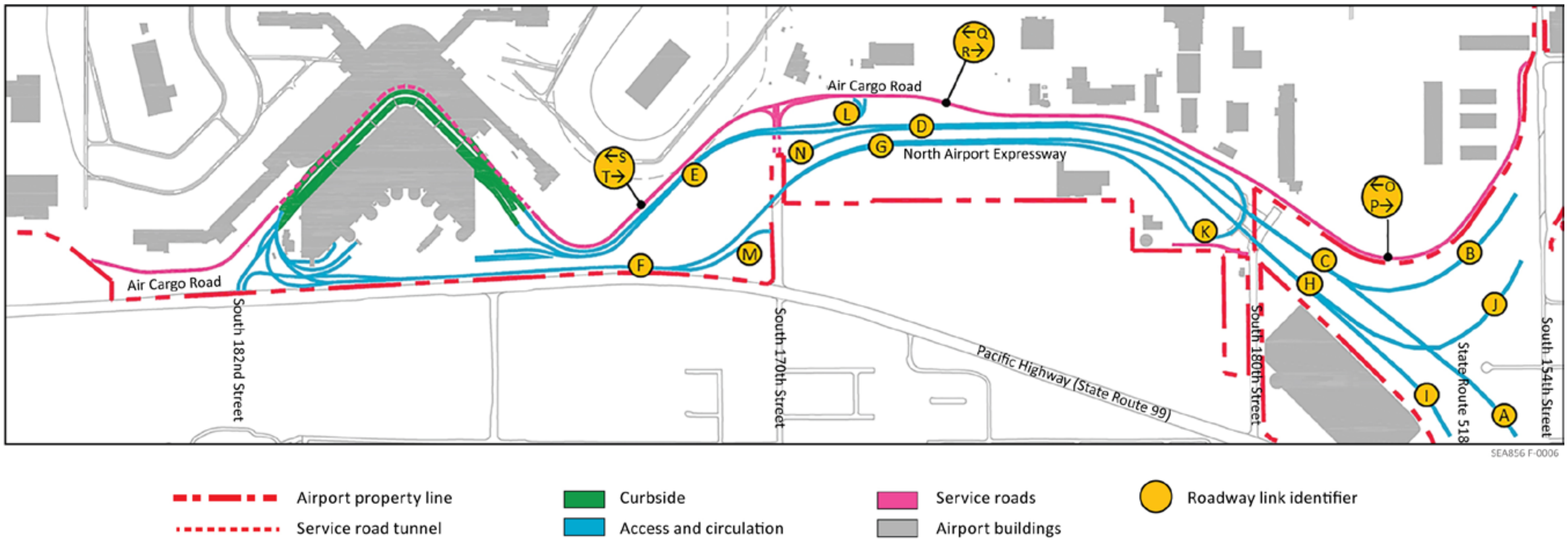


VC Ratio - 2010 Existing

DRAFT FIGURE

Source: Port of Seattle, 2017.

Figure 4-3
On-Airport Access Roadways
Seattle-Tacoma International Airport



Note: Roadway link identifiers are keyed to data presented in Table 4-1

Source: Inter*VISTAS*, from background map provided by Shen Consulting.

Table 4-1
Existing On-Airport Access Roadway Volumes, Capacities, and Levels of Service
Seattle-Tacoma International Airport

	Description	Assumed speed	Basic capacity per lane *(a)*	Heavy vehicle factor	Population factor	Capacity per lane	Lanes	Capacity	2010 volume *(b)*	Volume/ capacity ratio	Level of service *(a)*
A	Ramp from SR 518, westbound	50	2,000	0.95	0.85	1,620	2	3,240	1,590	0.49	C
B	Ramp from SR 518, eastbound	40	1,750	0.95	0.85	1,410	1	1,410	630	0.45	C
C	North Airport Expressway, southbound, prior to return-to-terminal ramp	40	1,750	0.95	0.85	1,410	3	4,230	2,220	0.52	C
D	North Airport Expressway, southbound, after return-to-terminal ramp	40	1,750	0.95	0.85	1,410	3	4,230	2,418	0.57	C
E	Terminal area entrance	30	1,450	0.95	0.85	1,170	4	4,680	2,477	0.53	C
F	Terminal area exit to north	40	1,750	0.95	0.85	1,410	4	5,640	2,367	0.42	C
G	North Airport Expressway, northbound, prior to return-to-terminal ramp	40	1,750	0.95	0.85	1,410	5	7,050	2,025	0.29	B
H	North Airport Expressway, northbound, after return-to-terminal ramp	40	1,750	0.95	0.85	1,410	3	4,230	1,827	0.43	C
I	Ramp to SR 518, eastbound	50	2,000	0.95	0.85	1,620	2	3,240	1,341	0.41	C
J	Ramp to SR 518, westbound	45	1,900	0.95	0.85	1,530	2	3,060	486	0.16	A
K	Return-to-terminal ramp	25	1,250	0.95	0.85	1,010	2	2,020	198	0.10	A
L	On-ramp from Air Cargo Road	25	1,250	0.8	1.0	1,000	2	2,000	277	0.14	A
M	Northbound exit to South 170th Street	25	1,250	0.8	1.0	1,000	1	1,000	342	0.34	B
N	Southbound exit to South 170th Street	25	1,250	1.0	1.0	1,250	1	1,250	218	0.17	A
O	Air Cargo Road, southbound, north of South 160th Street	35	1,600	0.75	1.0	1,200	2	2,400	215	0.09	A *(c)*
P	Air Cargo Road, northbound, north of South 160th Street	35	1,600	0.75	1.0	1,200	2	2,400	143	0.06	A *(c)*
Q	Air Cargo Road, southbound, north of South 170th Street	35	1,600	0.75	1.0	1,200	1	1,200	114	0.10	A *(c)*
R	Air Cargo Road, northbound, north of South 170th Street	35	1,600	0.75	1.0	1,200	1	1,200	39	0.03	A *(c)*
S	Air Cargo Road, southbound, south of South 170th Street	35	1,600	0.75	1.0	1,200	1	1,200	--	0.00	A *(c)*
T	Air Cargo Road, northbound, south of South 170th Street	35	1,600	0.75	1.0	1,200	1	1,200	--	0.00	A *(c)*

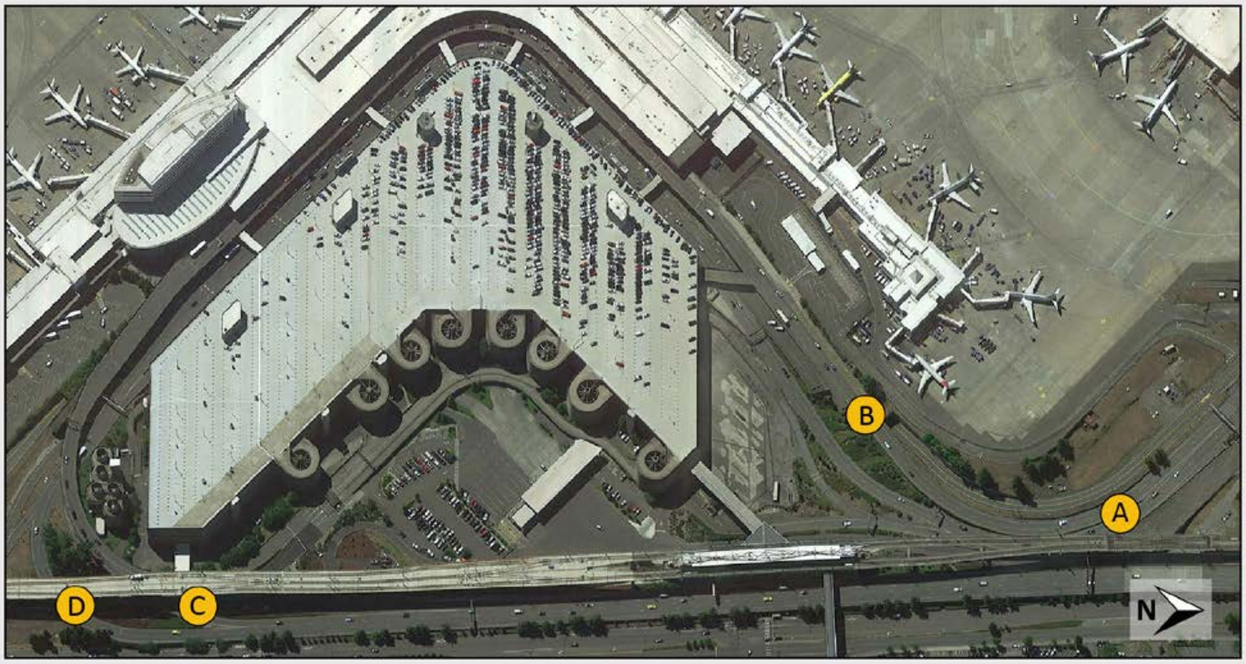
(a) Based on Airport Cooperative Research Program (ACRP) Report 40, Table 4-1.
(b) Provided by the Port of Seattle.
(c) Traffic conditions also impacted by intersections and truck turning movements.

Source: Inter*VISTAS*, from traffic volume data provided by the Port of Seattle.

4.2.3 Terminal-Area Circulation Roadways

Figure 4-4 depicts key terminal-area circulation roadways and identifies the four that currently experience the highest volumes and congestions.

Figure 4-4
Key Terminal-Area Roadways
Seattle-Tacoma International Airport



LEGEND
- A Approach to Lower Drive, including access to the Main Garage and the 3rd floor Commercial Vehicle Curb.
- B Approach to Upper Drive
- C Exit from Upper Drive to northbound North Airport Expressway
- D Exit from Lower Drive to northbound North Airport Expressway

Source: Inter*VISTAS* Inc., 2016.

Table 4-2 summarizes the 2014 volume, capacity, and level of service for each roadway segment identified in Figure 5-4. As shown, of the four key segments, the approach to the Lower Drive (which, in addition to curbside traffic, includes all traffic entering the 3rd floor courtesy vehicle lanes and approaching the Main Garage from the north) and the exit from the Upper Drive operate at level-of-service E. These conditions result in traffic backing up into upstream facilities, such as the Upper Drive and North Airport Expressway.

Table 4-2
Terminal-Area Circulation Existing Conditions
Seattle-Tacoma International Airport

Roadway segment *(a)*	Existing lanes	Per lane capacity (vehicles per hour)	Capacity (vehicles per hour)	Volume *(b)*	Volume/ capacity ratio	Level of service
A. Approach to Lower Drive	2	1,250	2,500	2,110	0.84	E
B. Approach to Upper Drive	2	1,250	2,500	1,240	0.50	C
C. Exit from Upper Drive to North Airport Expressway	1	1,450	1,450	1,240	0.86	E
D. Exit from Lower Drive to North Airport Expressway	2	1,450	2,900	1,210	0.42	C

(a) The locations for roadway segments are identified on Figure 5-4.
(b) Volumes represent the peak hour for the specific roadway and may not be concurrent.

Source: Inter*VISTAS* Inc., 2016.

4.2.4 Curbside Roadways

Currently, the Airport Main Terminal is accessed by two curbside roadways: the Upper Drive and Lower Drive. The Upper Drive provides approximately 1,200 linear feet of curb and four roadway lanes while the Lower Drive provides approximately 1,500 linear feet of curb and five roadway lanes. Approximately one-third of the curb length on the Lower Drive is reserved for public transit buses and shuttle buses serving the rental car facility.

Table 4-3 summarizes 2014 peak period traffic volumes on each curbside roadway, the curbside utilization ratio, the roadway volume/capacity ratios, and the corresponding level-of-service. As shown, with the assumed dwell times most of the curbs would operate in acceptable conditions. In practice, however, the curbs are extremely congested due to:

- Dwell times typically exceed those shown on Table 4-3, resulting in higher numbers of parked vehicles. The dwell times represent typical achievable dwell times when curbside dwell policies are enforced.
- Near the rental car shuttle loading areas, curb area and roadway capacity is reduced to facilitate shuttle bus maneuverability.
- On the Lower Drive, public transit buses, rental car shuttles, and other large vehicles may off-track around the curve in the middle of the roadway and obstruct adjacent lanes.

Table 4-3
Curbside Roadway Existing Conditions
Seattle-Tacoma International Airport

	Peak hour volume	Dwell times (minutes)	Average spaces	Peak spaces	Occupied curb length	Curb utilization	Level of service *(a)*	Roadway capacity *(a)*	Roadway volume/ capacity ratio	Level of service *(a)*
Upper Drive										
Private vehicles	953	2	31.8	-	-	-	-	-	-	-
Taxicabs	140	2	4.7	-	-	-	-	-	-	-
Limousines	96	2	3.2	-	-	-	-	-	-	-
Shared ride vans	22	2.5	0.9	-	-	-	-	-	-	-
Scheduled vans/buses (Airporters)	13	6	1.3	-	-	-	-	-	-	-
Charter buses	2	10	0.3	-	-	-	-	-	-	-
Other vehicles	14	3	0.7	-	-	-	-	-	-	-
Total	1,240		42.9	54	1,387	1.16	C	2,680	0.46	C
Lower Drive										
Private vehicles	1,104	2	36.8	50	1,250	1.19	C	-	-	-
Rental car shuttle	138 *(b)*	3.5	8.1	8	480	1.33	F *(c)*	-	-	-
Public transit	8 *(c)*	2	0.3	2	120	1.00	C	-	-	-
Total	1,250							3,100	0.40	C

(a) Based on Airport Cooperative Research Program (ACRP) Report 40, Table 5-2.
(b) Based on schedule required for 2,000 passengers per hour (55 second headways).
(c) This vehicle cannot double-park; curb utilization exceeding 1 represents deficient conditions.
(d) Assumes 3 routes operating in two directions at 10-minute headways.

Source: Inter*VISTAS*, October 2016.

4.2.5 Commercial Vehicle Facilities

The services provided by commercial vehicle operators at the Airport are provided by the following categories of services, service providers, and vehicles:

- **On-demand services**. These services are provided by taxis, limousines, and door-to-door vans which are currently allowed to drop-off customers on the Departures Curbside and pick-up customers in the Ground Transportation Center. Staging facilities are currently provided adjacent to the passenger pick-up area, and remote holding facilities are provided in the S 160th Street Ground Transportation Lot.

- **Pre-arranged services.** These services are provided by limousines and town cars which are currently allowed to drop-off customers on the Departures Curbside and pick-up customers either in the Ground Transportation Center or Arrivals Curbside (vehicle staged in the Ground Transportation Center). No remote holding facilities are provided for these services.

- **Transportation network companies**. These companies (e.g., Uber and Lyft) are currently allowed to drop-off customers on the Departures Curbside and pick-up customers in the Ground Transportation Center. Remote holding facilities are provided for these services in the South 160th St Ground Transportation Lot. (This service was introduced at the Airport after the 2014 base year and thus

- **Courtesy vehicles**. These include courtesy vehicles for off-site hotels/motels and parking facilities which are required to drop-off and pick-up customers in the Courtesy Vehicle Plaza. No staging or holding facilities are provided for these services.

- **Airporters**. These are typically scheduled services between regional destinations (e.g., San Juan Islands and Olympia) and the Airport. Airporters are currently allowed to drop-off customers on the Departures Curbside and pick-up customers in the South Ground Transportation Lot. Remote holding facilities are provided in the South Ground Transportation Holding Lot.

- **Rental car buses**. These include the consolidated bus service that transports rental car customers between the Terminal and the remote consolidated Rental Car Facility. Customers are currently dropped-of and picked-up from the dedicated busing zones at the north and south ends of the Arrivals curbside. Staging facilities are provided at the Rental Car Facility.

- **Cruise charter buses**. These include charter buses that transport passengers between the downtown cruise terminals and the Airport. Cruise ship charter buses currently operate from May through September and are allowed to drop-off customers in the North Charter Bus Lot and South Ground Transportation Lot, and pick-up customers in the South Ground Transportation Lot. Panel vans are also used to help transport cruise passenger baggage from the Airport to the cruise terminals downtown. Remote holding facilities are provided in the South Ground Transportation Holding Lot.

- **Other charter buses**. These include military and other group charter buses which are currently allowed to drop-off customers on the Departures Curbside and pick-up customers in the South Ground Transportation Lot. Remote holding facilities are provided in the South Ground Transportation Holding Lot.

- **Public transit**. Public transit services are operated by Metro, Sound Transit, Pierce Transit, and Paratransit. These services currently drop-off and pick-up transit customers on International Blvd and the south end of the Arrivals curbside.

- **Crew vans**. These services are scheduled by the airlines, dependent upon the need to overnight airline crews in Seattle, and currently allowed to drop-off customers on the Departures Curbside or Courtesy Vehicle Plaza, and pick-up in the South Ground Transportation Lot of Courtesy Vehicle Plaza.

Table 4-4 summarizes the existing commercial facilities utilized for each transit mode. As shown, existing facilities are generally sufficient to accommodate the 2014 demand. The commercial vehicle lanes on the 3rd floor of the Main Garage, however, experience congestion due to limited capacity of the two-lane roadway and multiple pedestrian crossings.

Table 4-4
Summary of Existing Commercial Vehicle Facilities
Seattle-Tacoma International Airport

	Facility capacity (spaces)				2014 Demands			
Service	Drop-off	Pickup	Staging	Holding	Drop-off	Pickup	Staging	Holding
On Demand Services								
Taxis	n.a. *(a)*	13	70	98	n.a.	9	48	98
Town Cars/Limousines	n.a. *(a)*	2	5	n.a.	n.a.	1	2	n.a.
Door-to-Door Vans	n.a. *(a)*	8	n.a.	n.a.	n.a.	3	5	n.a.
Town Cars/Limousines	n.a. *(a)*	48	n.a.	n.a.	n.a.	8	n.a.	n.a.
Trans Network Companies	n.a. *(a)*	57	n.a.	43	n.a.	n.a.	n.a.	n.a.
Courtesy Vehicles *(c)*	n.a. *(b)*		n.a.	n.a.	n.a.	20	n.a.	n.a.
Crew Vans	n.a. *(a) (b)*	22	n.a.	n.a.	n.a.	1	n.a.	n.a.
Downtown Shuttle	n.a. *(a)*		n.a.	n.a.	n.a.	2	n.a.	n.a.
Airporters (Vans and buses)	n.a. *(a)*	3	n.a.	6	n.a.	2	n.a.	6
Charter Buses								
Cruise (Bus)	20		n.a.	15	8	6	n.a.	15
Cruise (Truck)	n.a.	6	n.a.	n.a.	n.a.	6	n.a.	n.a.

(a) Service drops off customers on the Departures curbside.
(b) Service drops off and picks up customers in the Courtesy Vehicle Plaza.
(c) Service drops off and picks up customers in the same stall.

Source: Inter*VISTAS* and Port of Seattle, June 2016.

4.2.6 Public Parking

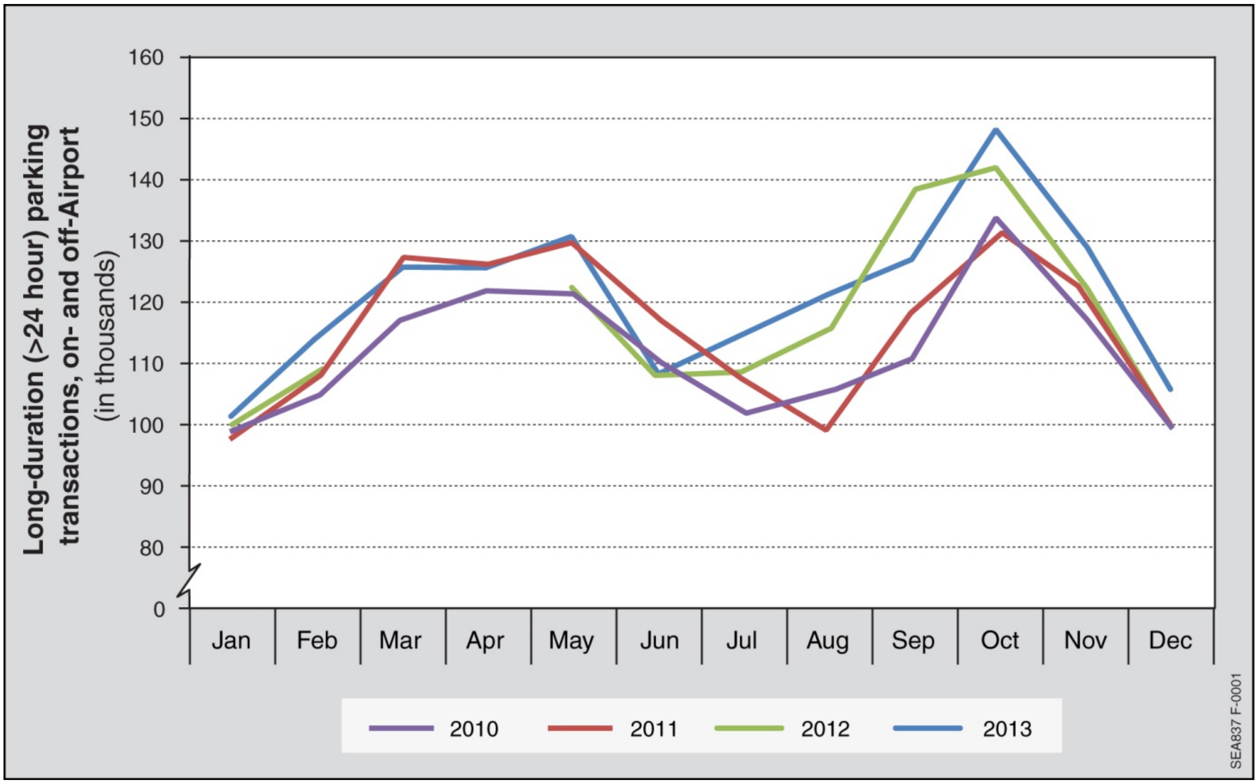
Public parking is currently provided in the Main Garage, the Doug Fox Lot (operated by a third-party concessionaire), and multiple off-Airport parking and hotel/motel operators.

Existing needs (and future requirements) are based on a 'design day' that represents the parking demand for a typical busy day during the year, but does not represent the highest day of the year. At an airport, there may often be a limited number of days, such as holidays, where parking demand is significantly higher than during all other days of the year. Airport operators often elect to not plan for permanent parking facilities (such as garages and paved surface lots) that would accommodate the highest days of the year because some of those spaces would rarely be used and thus, not generate revenue sufficient to justify paying to construct the space. Therefore, the design day is used as the level of demand an airport aims to accommodate with permanent parking facilities.

The design day may also occur (and at many airports, does occur) during a time of the year outside of an airport's peak month for airline passenger activity. This is because an airport's peak month for airline passengers may reflect high volumes of leisure travelers and/or visitors (as opposed to residents), both of which are typically less likely to park at the airport for the duration of their trip. These customers may generate high volumes of parking transactions, but as these transactions are typically for less than 4 hours each, they do not result in high numbers of accumulated parked vehicles. Therefore, an airport's design day for parking is more likely to occur during a month experiencing high volumes of local passengers travelling for business reasons as these passengers are more likely to park at the airport for the duration of their trip. These long-duration transactions, while lower in volume, typically result in high numbers of accumulated parked vehicles as each vehicle may remain parked for several days.

Figure 4-5 depicts combined monthly long-duration parking transactions (transactions exceeding 24 hours) for the Main Garage and off-Airport parking facilities located in the cities of SeaTac, Tukwila, and Burien. As shown, from 2010 through 2013 the highest number of long-duration transactions occurred in October whereas the peak month for airline passengers was typically July or August.

Figure 4-5
Long-Duration Parking Transactions, 2010 – 2013
Seattle-Tacoma International Airport

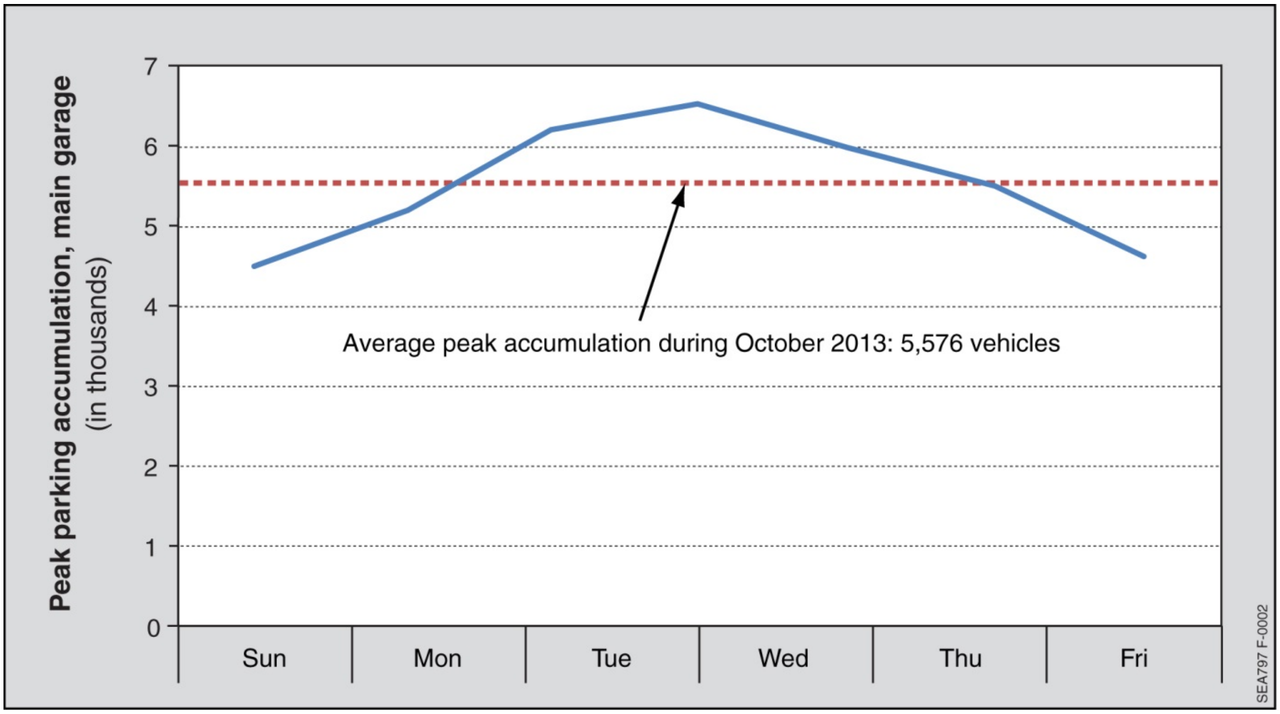


Source: LeighFisher, from data provided by the Port of Seattle.

Because parking accumulations are typically comprised mostly of long-duration parkers and thus, reflect the accumulation over multiple days of activity, the 'average' day during a given month will not accurately reflect the actual demand for parking. Figure 4-6 depicts the average peak accumulations in the Main Garage for October 2013 for each day of the week as well as for the average day of the month. As shown, the average occupancy during the month is exceeded by the occupancies experienced on an average Tuesday, Wednesday, and Thursday. Thus, basing parking requirements on the 'average day' occupancy would likely result in many days (up to 12 days in October, alone) where actual demand exceeded capacity.

Due to the disconnect between peak parking demands and peak month airline passengers, as well as the likelihood that using an average day during a month would underestimate true peak period demands, a 'design day' was selected using the method described below.

Figure 4-6
Average Daily Parking Accumulation in the Main Garage, October 2013
Seattle-Tacoma International Airport



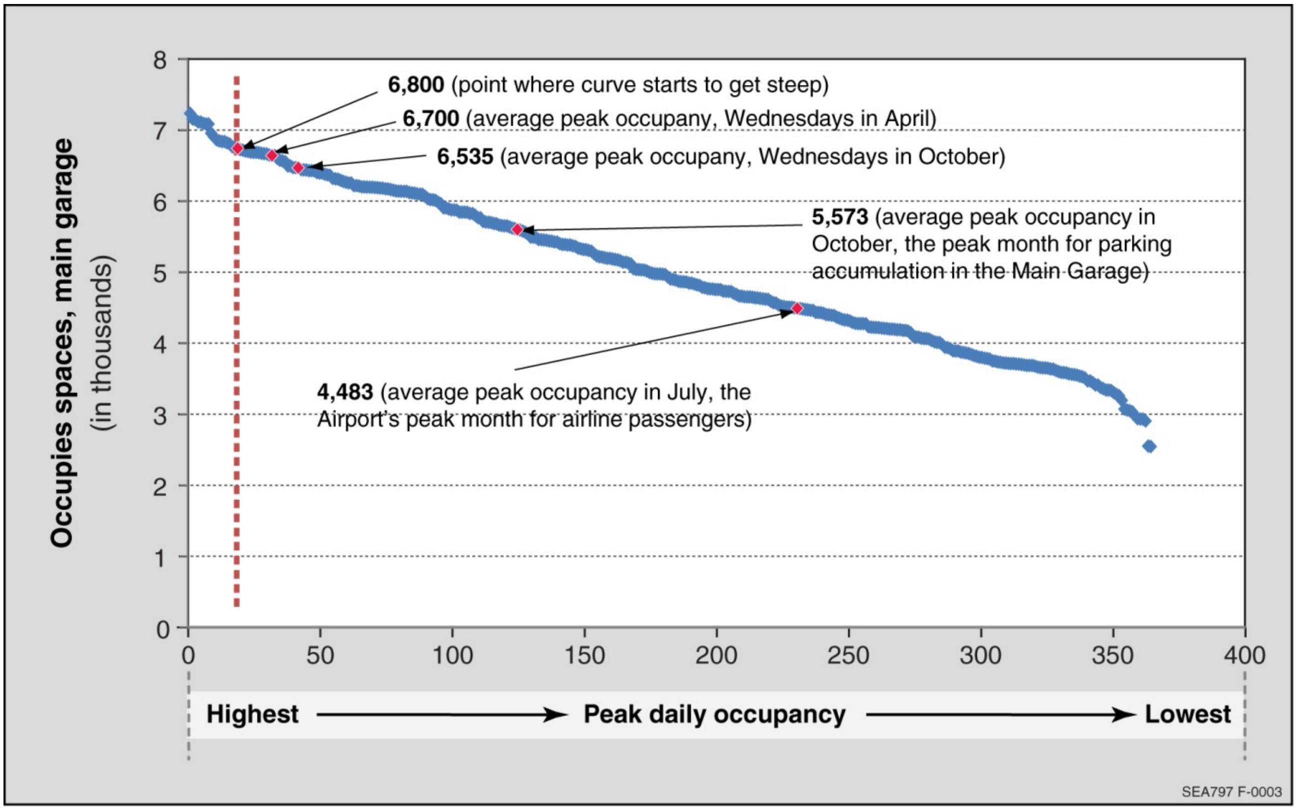
Source: LeighFisher, from data provided by the Port of Seattle.

4.2.6.1 Main Garage

Baseline design day peak occupancy was determined by evaluating the observed midday occupancies for the Main Garage for each day in 2013. Figure 5-7 depicts the observed midday occupancies for the Main Garage for each day in 2013. The observed occupancies, when sorted highest to lowest (regardless of when they occurred during the year), form the S-curve shape shown on Figure 4-7. The 'design day' value was selected by identifying the point on the left side S-curve where the slope transitioned from vertical to horizontal. This point represents the occupancy value exceeded by a very limited number of days (such as holidays), but where using a lower value would mean many additional days would exceed the 'design day'. For comparison, four other days are identified as well:

- Average peak occupancy in October (the peak month for parking accumulation in the Main Garage in 2013)
- Average peak occupancy of Wednesdays in October (Wednesdays are typically the day experiencing the highest accumulations in the Main Garage)
- Average peak occupancy of Wednesdays in April (the month with the highest average Wednesday occupancy)
- Average peak occupancy in July (which reflects accumulations during an average day during the Airport's peak month for airline passengers)

Figure 4-7
Main Garage Peak Occupancies, 2013
Seattle-Tacoma International Airport



Source: Parking occupancy data provided by the Port of Seattle.

The point identified on the S-Curve, 6,800 occupied parking spaces, was selected as the design day occupancy value for peak accumulations of parking. There are approximately 15 days where peak occupancies were noticeably higher than the selected value whereas a reduction in the selected value would mean there would be many additional days where overnight occupancy exceeded the design day value. This value is also similar to the observed peak accumulations during an average Wednesday in April.

Of the 6,800 occupied spaces, April 2013 transactions-by-duration were evaluated to estimate the number of spaces occupied by short-duration versus long-duration parkers. As shown on Table 4-5, April 2013 transactions-by-duration were adjusted by two factors to estimate the share of occupied spaces during the 'design day' associated with each duration transaction. The first factor, a 'month-to-day' conversion factor, adjusts monthly transactions to reflect transactions occurring during a typical busy day. The second factor, the 'turnover factor', reflects the number of spaces required to accommodate a transaction of certain durations during the typical busy day. For transactions exceeding one day, this factor results in a single daily transaction requiring multiple spaces (i.e., a two-day transaction requires approximately two spaces) to reflect the accumulation of vehicles from prior days. The month-to-day and turnover factors were manually adjusted (using professional judgement and experience with typical values for these factors) such that the calculated occupied spaces matched the design day value of 6,800 vehicles. As shown, of the 6,800 spaces, approximately 1,300 (approximately 19%) are estimated to be related to parking transactions of less than 24 hours.

Table 4-5
Estimated Main Garage Occupied Spaces,
By Parking Duration, April 2013
Seattle-Tacoma International Airport

Parking duration	April 2013	Design day	Turnover	Occupied spaces
0 to 3 hours	97,721	3,370	3.50	963
3 to 12 hours	8,719	301	2.00	150
12 to 24 hours	5,712	197	1.00	197
Subtotal				1,310
1 to 2 days	12,345	426	0.54	794
2 to 3 days	11,189	386	0.35	1,106
3 to 4 days	7,906	273	0.26	1,054
4 to 5 days	4,645	160	0.21	779
5 to 6 days	2,298	79	0.17	465
6 to 7 days	1,309	45	0.15	310
7 to 14 days	2,929	101	0.11	895
Over 14 days	139	5	0.06	87
Subtotal				5,490
Total				6,801

Note: Main Garage design day demand is to be revised to (a) reflect 2014 activity and (b) identify employee share of design day demand.]

Source: LeighFisher from data provided by the Port of Seattle.

4.2.6.2 Doug Fox Lot

Peak occupancy data is currently unavailable for the Doug Fox Lot. For purposes of quickly estimating preliminary future requirements, visual inspection during LeighFisher on-site meetings in late 2014 indicated the facility was approximately 50% full (800 occupied spaces) during a typical busy day. This value was compared with estimated Doug Fox Lot occupancies prepared by LeighFisher (as part of a separate planning assignment) in 2012 using 2011 transaction and revenue data, which indicated Doug Fox Lot accumulations of approximately 900 vehicles. Given that 2013 Doug Fox Lot transactions were approximately 13% below the volume of 2011 Doug Fox Lot transactions, the estimated 2013 occupancy of 800 vehicles was determined to be reasonable.

4.2.6.3 Off-Airport Parking Facilities

Peak occupancy data is unavailable for the numerous off-Airport parking facilities serving the Airport. For purposes of estimating preliminary future requirements, it was assumed that the facilities were approximately 80% full during typical busy periods, which was based on estimated occupancies observed during a 2006 LeighFisher visual survey of off-Airport parking facilities. Thus, of the estimated off-Airport capacity of 18,500 spaces, design day demand was estimated to be approximately 15,000 spaces. To validate this assumption, the ratio of off-Airport parking transactions in 2013 versus 2006 (896,000 versus 801,000, a ratio of 1.12) was applied to the estimated 2006 off-Airport parking accumulations (approximately 13,000 vehicles), resulting in an estimated 2013 accumulation of approximately 14,600. Thus, the value of 15,000 was deemed sufficient for purposes of estimating preliminary parking requirements.

4.2.6.3 Summary of Existing Demands

Table 4-6 summarizes existing public parking needs. As shown, the 2014 demands could be accommodated within the available capacity.

Table 4-6
Existing Public Parking Facility Demands
Seattle-Tacoma International Airport

	Design day demand	Parking requirement *(a)*	Existing capacity
Short-duration (less than 24 hours) *(b)*	1,310	1,440	
Long-duration (greater than 24 hours)			
Main Garage *(d)*	5,490	6,040	12,800
Doug Fox Lot	800	880	1,620
Off-Airport facilities	15,000	16,500	18,500
Long-duration subtotal	21,290	23,420	
Total	22,601	24,860	32,920

(a) Includes a 10% circulation factor.
(b) All short-duration parking is assumed to occur in the Main Garage.

Source: LeighFisher, from data provided by the Port of Seattle.

4.2.7 Employee Parking

Airport-wide employee parking is currently provided in the North Employee Parking Lot (NEPL) and to a limited extent in the Main Terminal Garage. The employee parking operation supports the employee parking needs of the airline tenants, the Airport Dining and Retail (ADR) program tenants, Port of Seattle, federal agencies, and other Airport-related services. The employee parking program does not support rental car or other offsite stand-alone facilities (e.g., flight kitchens).

Table 4-7 summarizes the existing employee parking facilities and level of activity associated with airline, ADR, cargo/maintenance, and other airport functions. The key observations related to existing employee parking operations include the following:

- Based on the May 2016 activity report and existing facilities, a total of approximately 6,195 parking stalls are currently in-use for employee parking.

- The existing May 2016 level of activity in the NEPL was reviewed on a day-by-day basis to determine the level of use or occupancy of that facility. As identified in Table 4-7, the NEPL is currently operating at 85% occupancy. There are also a total of 10,006 access cards in use which correlates to 2.4 access cards per parking stall.
- For passenger terminal-related functions, 84% of employees currently park in NEPL and 16% park in the Main Terminal Garage. The employees that park in the Main Terminal Garage generally include Port of Seattle, federal agencies, and a limited number of Airport tenant employees based upon tenant agreements.
- For the cargo and aircraft maintenance functions the majority of the parking needs are currently met on-site (95%). For these on-site facilities, an average of 1.4 parking stalls are provided for every 1,000 SF of cargo or aircraft maintenance facility space.

Table 4-7
Existing Airport-wide Employee Parking Facilities and Use
Seattle-Tacoma International Airport

	Existing Facilities								
	Facility *(a)*	Access Cards *(b)*				Parking Stalls			
Description	Space (sf)	NEPL	MG	Other	Total	NEPL *(c)*	MG	Other	Total
Port of Seattle/Agencies	n.a.	378	1,683	0	2,061	158	701	0	859
Airline Terminal Operations	1,137,400	8,030	72	0	8,102	3,346	30	0	3,376
Airport Dining & Retail *(d)*	285,793	281	54	0	335	117	23	0	140
Other/Not Defined *(d)*	n.a.	1,158	0	0	1,158	435	0	0	435
Terminal Subtotal	285,793	9,847	1,809	0	9,595	4,056	754	0	4,810
						84%	16%	0%	
North Cargo Facilities *(c)*	375,700	159	0	0	159	66	0	455	521
Central Cargo Facilities *(e)*	174,300	0	0	0	0	0	0	249	249
United Maintenance *(c)*	Unknown	0	0	0	0	0	0	169	169
Alaska Maintenance *(c)*	150,000	0	0	0	0	0	0	283	283
Delta Cargo/Maintenance *(c)*	196,000	0	0	0	0	0	0	115	115
FAA air traffic control tower *(c)*	n.a.	0	0	0	0	0	0	48	48
Cargo/maintenance Subtotal	896,000	159	0	0	159	66	0	1,319	1,385
						5%	0%	95%	
Totals		**10,006**	**1,809**	**0**	**9,754**	**4,122**	**754**	**1,319**	**6,195**
						67%	12%	21%	

NEPL = North employee parking lot
MG = Main garage

(a) From Aviation/Properties Terminal Space Reconciliation 2016 Settlement Report or Aviation/Property lease records.
(b) From Airport Operations Employee Parking May 2016 billing report.
(c) The number of parking stalls is based upon aerial photographs of existing facilities.
(d) The number of parking stalls was calculated assuming 2.4 access cards per parking stall.
(e) Estimated using an average of one parking stall per 700 SF of cargo building.

Source: Port of Seattle, October 2016.

4.2.8 Rental Car Facilities

In 2011, the Port opened the Rental Car Facility (RCF), located on South 160th Street. This facility provides approximately 1.7 million square feet of space for customer counters, ready/return vehicles, quick-turn-around (QTA) functions, and vehicle storage. The facility was sized to accommodate rental car demands expected to occur when the Airport serves 57 MAP.

The existing facilities appear to be meeting the needs of the rental car operators and customers. Identified deficiencies relate predominately to the shuttle bus operations at the Main Terminal curbsides.

4.2.9 Non-motorized Access

Passengers and employees arriving on foot or bicycle on local streets can safely access the Airport terminal at three locations:

- **Intersection of S 188th St & 28th Ave S**. A shoulder on the west side of 28th Ave S becomes a paved path where the City right of way transitions to a limited access roadway. This path leads to the Gina Marie Lindsay Arrivals Hall at the baggage claim level of the terminal.

- **Intersection of S 182nd St & International Blvd**. A sidewalk at the southwest corner of the intersection runs along the south side of the terminal curb exit lanes curb and leads to the Gina Marie Lindsay Arrivals Hall at the baggage claim level of the terminal.

- **Intersection of S 176th St & International Blvd**. An elevator and stairs at the Sound Transit Kiss & Ride facility at the northeast corner of the intersection leads to a pedestrian bridge that access the Light Rail Station and northeast corner of the Airport parking garage on level 4. A designated walkway along the interior perimeter of the parking garage leads to several pedestrian bridges accessing the mezzanine level of the terminal.

Passengers and employees can also access the terminal with their bicycle using public transit vehicles serving the Airport:

- **Link Light Rail**. The mezzanine level of the terminal can be accessed from the Light Rail station via a designated walkway along the interior perimeter of the parking garage and pedestrian bridges.

- **King County Metro Bus**. Three routes serve the Airport with stops at S 176th St and S 182nd St (Route 156, Route 180 & RapidRide A Line).

- **Sound Transit Express Bus**. Two routes serve the Airport with stops at the south end of the arrivals curb at the baggage claim level of the terminal (Route 560 & Route 574).

4.2.10 Cruise Ship Facilities

Cruise ship facilities at the airport are a seasonal operation from late-April through early-October. During this time, the existing cruise ship operation processes passengers at the north and south ends of the Main Terminal.

Cruise passengers arriving from the waterfront are dropped off in the North Charter Bus Lot (NCBL) for those airlines with check-in functions located in the north half of the Main Terminal. Cruise passengers arriving from the waterfront are dropped off in the South GT (Ground Transportation) Lot for those airlines with check-in functions located in the south half of the Main Terminal. Facilities for boarding pass and bag drop are located at the NCBL and South GT for those airlines that choose to staff these areas. Passengers arriving from the waterfront also have the ability to print their boarding pass inside the Main Terminal (at either a Port Common Use Self-Service (CUSS) kiosk for certain airlines, or at an airline proprietary kiosk), and drop bags where their airline is located.

Passengers who fly into Sea-Tac and depart for the waterfront board buses at the South GT Lot, unless they make alternate arrangements for transportation to the waterfront. Many passengers who make alternate arrangements to get to the waterfront have a "land tour package" as part of their itinerary and board their cruise ship on a different day.

As an alternative to check-in at the airport, some cruise ship lines are working with a third party service, like Bags Inc., that provides a fee-based service where passengers can print their boarding pass and check their bag on the cruise ship.

In 2017 the cruise ship operation in the NCBL will be permanently displaced in the north due to construction of a holdroom for passengers bused to remote gates, and at the South GT Lot due to construction of the IAF (International Arrivals Facility). Alternate facilities and operations have been developed by Airport Operations to accommodate this impact; however, this is not intended to be a long-term solution.

4.3 Desired Ground Access and Parking Characteristics and Planning Assumptions

The facilities requirements presented in this section generally reflect the goal to provide facilities that operate at Level of Service (LOS) C or better during the peak hour. This goal reflects the potentially severe consequences of delay for passengers traveling to the Airport, such as customers missing flights. For the purposes of defining LOS associated with ground access facilities, we have used North American highway LOS standards from the Transportation Research Board's Highway Capacity Manual, using letters A through F, with A being the best and F being the worst. The following summarize these levels of service:

- **LOS A – free flow**. At LOS A, traffic flows at or above the posted speed limit and motorists have complete mobility between lanes.

- **LOS B – reasonably free flow**. At LOS B, traffic maintains LOS A speeds but maneuverability within the traffic stream is slightly restricted.

- **LOS C – stable flow**. At LOS C traffic experiences near free flow but he ability to maneuver through lanes is noticeably restricted and lane changes require more driver awareness.

- **LOS D – approaching unstable flow**. At LOS D, traffic speeds slightly decrease as traffic volume slightly increases; the freedom to maneuver within the traffic stream is much more limited and driver comfort levels decrease.

- **LOS E – unstable flow**. At LOS E, roadway facilities are operating at capacity; traffic flow becomes irregular and speed varies rapidly because there are virtually no usable gaps to maneuver in the traffic stream and speeds rarely reach the posted limit.

- **LOS F – forced or breakdown flow**. At LOS F, every vehicle moves in lockstep with the vehicle in front of it, with frequent slowing required; travel time cannot be predicted, and demand generally exceeds capacity.

For parking facilities, LOS C represents conditions where demand is 90% or less of capacity, recognizing the increasing difficulty of finding available spaces until higher occupancies.

4.4 Ground Access and Parking Facility Requirements

This section presents the requirements for those ground access and parking facilities that will most influence the development of alternatives. The approaches and key assumptions in estimating the requirements are described in the following paragraphs.

4.4.1 Off-Airport Access Roadways

This section summarizes the projected regional traffic conditions at 2035, near the end of the SAMP planning period. Figure 4-8 depicts the regional model V/C ratios for key roadways in the Airport vicinity. As shown, in addition to further degradation of conditions on the regional facilities experiencing congestion in 2010 (such as the I-5/I-405 interchange and southbound I-5), SR 509 and SR 518 are expected to experience V/Cs exceeding 0.8 (representing LOS E). However, conditions on I-405 are expected to improve.

4.4.2 On-Airport Access Roadways

As described in Section 4.2.1, the on-Airport roadway system includes the North Airport Expressway (NAE) that provides access to the curbsides, commercial ground transportation areas, main garage, and Air Cargo Road. All of these elements were evaluated by Port staff using the Sea-Tac Airport travel demand forecasting model for the afternoon peak hour, for the following scenarios:

- 2010 (see Section 4.2.1). This model assumed the Airport served approximately 31.5 MAP.

- 2025. In addition to the existing on-Airport roadways, this scenario assumes that an interim phased of South Access has been implemented. This model assumed the Airport served approximately 53.6 MAP.

- 2035. In addition to the existing on-Airport roadways, this scenario assumes that the future South Airport Expressway has been implemented providing a direct connection between the Airport terminal area and a future extension of SR 509. This model assumed the Airport served approximately 66.0 MAP.

To estimate future requirements, peak hour volumes from the model runs described above were adjusted as follows:

- For PAL 1 (2018): 2025 model, multiplied by 0.84 (ratio of 44.8 MAP to 53.6 MAP)

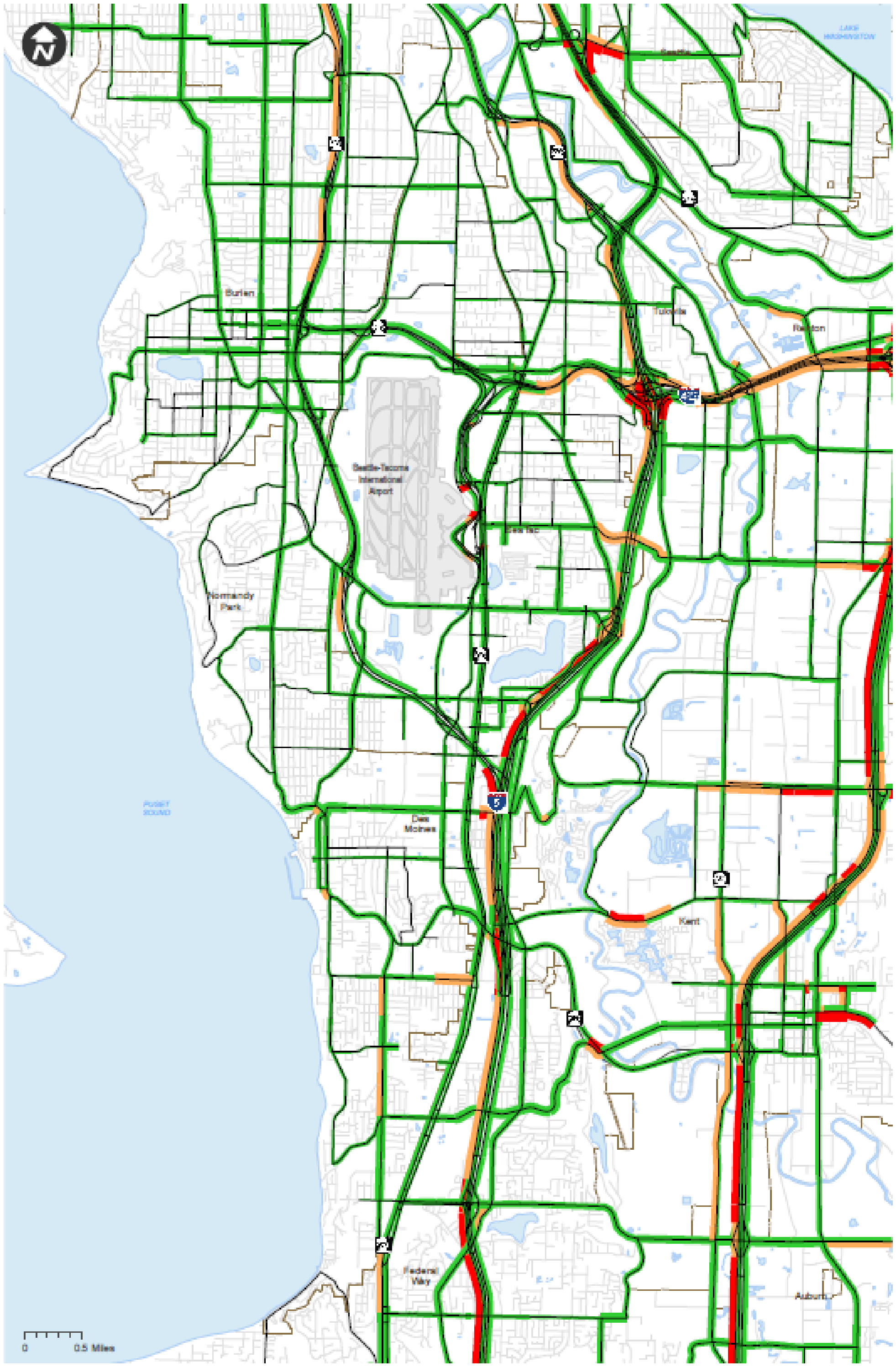
- For PAL 2 (2023): 2025 model, multiplied by 0.97 (ratio of 51.8 MAP to 53.6 MAP)

- For PAL 3 (2028): 2025 model, multiplied by 1.10 (ratio of 58.9 MAP to 53.6 MAP)

- For PAL 4 (2034): 2035 model, multiplied by 0.99 (ratio of 65.6 MAP to 66.0 MAP)

Figure 4-9 depicts key on-Airport access roadways described in Section 4.2, but also includes the future development of South Access and the South Airport Expressway. Due the development of the South Access and the South Airport Expressway, the regional model predicts that by 2035, approximately 77% of peak hour Airport traffic will access the Airport to and from the north via the North Airport Expressway (compared with 87% in 2010). As shown on Table 4-8 and 4-9, by PAL 2, additional capacity is required on the southbound North Airport Expressway and the southbound direction of the interim South Access roadway. By PAL 3, additional capacity is required on both inbound ramps from SR 518 as well as the outbound ramp to eastbound SR 518. By PAL 4, the South Airport Expressway will require additional capacity.

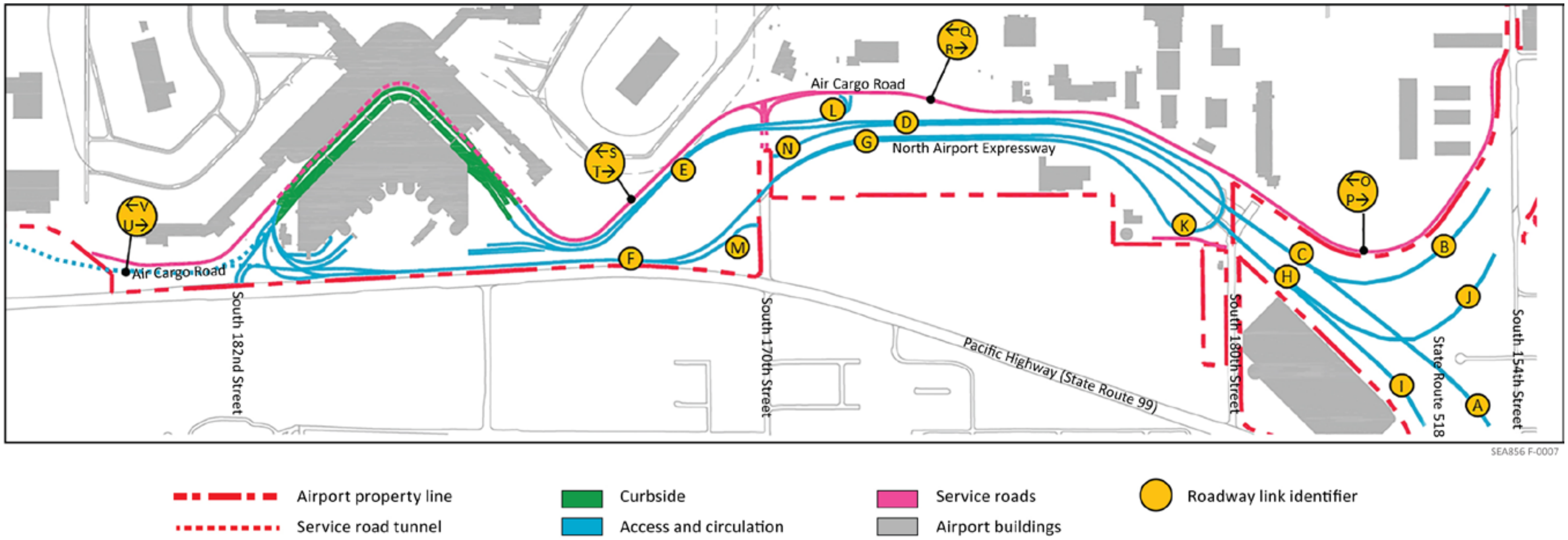
Figure 4-8
2035 Regional Traffic Conditions
Seattle-Tacoma International Airport



VC Ratio - 2035 SAE Existing Terminal DRAFT FIGURE

Source: Port of Seattle, 2017.

Figure 4-9
On-Airport Access Roadways with Future South Access and South Airport Expressway
Seattle-Tacoma International Airport



Note: Roadway link identifiers are keyed to data presented in Table 5-8.

Source: Inter*VISTAS*, from background map provided by Shen Consulting.

Table 4-8
Future On-Airport Access Roadway Volumes and Lanes Required to Achieve Los C or Better (PALS 1 and 2)
Seattle-Tacoma International Airport

		Existing (2014)							PAL 1				PAL 2			
Link identifier	Facility	Assumed speed (mph)	Basic capacity per lane *(a)*	Heavy vehicle factor	Population factor	Capacity per lane	Lanes	Capacity	Volume *(b)*	Volume/ capacity ratio	Level of service *(a)*	Lanes to achieve LOS C or better	Volume *(b)*	Volume/ capacity ratio	Level of service *(c)*	Lanes to achieve LOS C or better
A	Ramp from SR 518, westbound	50	2,000	0.95	0.85	1,620	2	3,240	1,828	0.56	C	2	2,114	0.65	D	3
B	Ramp from SR 518, eastbound	40	1,750	0.95	0.85	1,410	1	1,410	682	0.48	C	1	789	0.56	C	1
C	North Airport Expressway, southbound, prior to return-to-terminal ramp	40	1,750	0.95	0.85	1,410	3	4,230	2,511	0.59	C	3	2,904	0.69	D	4
D	North Airport Expressway, southbound, after return-to-terminal ramp	40	1,750	0.95	0.85	1,410	3	4,230	2,857	0.68	D	4	3,304	0.78	D	4
E	Terminal area entrance	30	1,450	0.95	0.85	1,170	4	4,680	2,798	0.60	C	4	3,236	0.69	D	5
F	Terminal area exit to north	40	1,750	0.95	0.85	1,410	4	5,640	2,557	0.45	C	4	2,957	0.52	C	4
G	North Airport Expressway, northbound, prior to return-to-terminal ramp	40	1,750	0.95	0.85	1,410	5	7,050	2,308	0.33	B	5	2,669	0.38	B	5
H	North Airport Expressway, northbound, after return-to-terminal ramp	40	1,750	0.95	0.85	1,410	3	4,230	1,962	0.46	C	3	2,269	0.54	C	3
I	Ramp to SR 518, eastbound	50	2,000	0.95	0.85	1,620	2	3,240	1,750	0.54	C	2	2,023	0.62	D	3
J	Ramp to SR 518, westbound	45	1,900	0.95	0.85	1,530	2	3,060	483	0.16	A	2	559	0.18	A	2
K	Return-to-terminal ramp	25	1,250	0.95	0.85	1,010	2	2,020	346	0.17	A	2	400	0.20	A	2
L	On-ramp from Air Cargo Road	25	1,250	0.8	1.0	1,000	2	2,000	253	0.13	A	2	292	0.15	A	2
M	Northbound exit to South 170th Street	25	1,250	0.8	1.0	1,000	1	1,000	248	0.25	A	1	287	0.29	B	1
N	Southbound exit to South 170th Street	25	1,250	1.0	1.0	1,250	1	1,250	311	0.25	A	1	360	0.29	B	1
O	Air Cargo Road, southbound, north of South 160th Street	35	1,600	0.75	1.0	1,200	2	2,400	251	0.10	A *(c)*	2	290	0.12	A *(c)*	2
P	Air Cargo Road, northbound, north of South 160th Street	35	1,600	0.75	1.0	1,200	2	2,400	162	0.07	A *(c)*	2	188	0.08	A *(c)*	2
Q	Air Cargo Road, southbound, north of South 170th Street	35	1,600	0.75	1.0	1,200	1	1,200	141	0.12	A *(c)*	1	162	0.14	A *(c)*	1
R	Air Cargo Road, northbound, north of South 170th Street	35	1,600	0.75	1.0	1,200	1	1,200	56	0.05	A *(c)*	1	65	0.05	A *(c)*	1
S	Air Cargo Road, southbound, south of South 170th Street	35	1,600	0.75	1.0	1,200	1	1,200	--	0.00	A *(c)*	1	--	0.00	A *(c)*	1
T	Air Cargo Road, northbound, south of South 170th Street	35	1,600	0.75	1.0	1,200	1	1,200	--	0.00	A *(c)*	1	--	0.00	A *(c)*	1
U	Interim South Access, northbound (d)	25	1,250	0.95	0.85	1,010	1	1,010	454	0.45	C *(c)*	1	525	0.52	C *(c)*	1
V	Interim South Access, southbound (d)	25	1,250	0.95	0.85	1,010	1	1,010	742	0.73	D *(c)*	2	858	0.85	E *(c)*	2

(a) Based on Airport Cooperative Research Program (ACRP) Report 40, Table 4-1.
(b) Based on volumes provided by the Port of Seattle.
(c) Traffic conditions also impacted by intersections and/or truck turning movements.
(d) Assumes interim South Access roadways are in-place by PAL 1.

Source: Inter*VISTAS*, from traffic volume data provided by the Port of Seattle.

Table 4-9
Future On-Airport Access Roadway Volumes and Lanes Required to Achieve Los C or Better (PALS 3 and 4)
Seattle-Tacoma International Airport

					PAL 3				PAL 4			
Link identifier	Facility	Assumed speed (mph)	Lanes	Capacity *(a)*	Volume *(b)*	Volume/ capacity ratio	Level of service *(c)*	Lanes to achieve LOS C or better	Volume *(b)*	Volume/ capacity ratio	Level of service *(c)*	Lanes to achieve LOS C or better
A	Ramp from SR 518, westbound	50	2	3,240	2,404	0.74	D	3	2,517	0.78	D	3
B	Ramp from SR 518, eastbound	40	1	1,410	897	0.64	D	2	974	0.69	D	2
C	North Airport Expressway, southbound, prior to return-to-terminal ramp	40	3	4,230	3,301	0.78	D	4	3,490	0.83	E	5
D	North Airport Expressway, southbound, after return-to-terminal ramp	40	3	4,230	3,756	0.89	E	5	4,064	0.96	E	5
E	Terminal area entrance	30	4	4,680	3,679	0.79	D	6	4,011	0.86	E	6
F	Terminal area exit to north	40	4	5,640	3,361	0.60	C	4	3,874	0.69	D	5
G	North Airport Expressway, northbound, prior to return-to-terminal ramp	40	5	7,050	3,035	0.43	C	5	3,396	0.48	C	5
H	North Airport Expressway, northbound, after return-to-terminal ramp	40	3	4,230	2,580	0.61	D	4	2,822	0.67	D	4
I	Ramp to SR 518, eastbound	50	2	3,240	2,300	0.71	D	3	2,452	0.76	D	3
J	Ramp to SR 518, westbound	45	2	3,060	636	0.21	A	2	723	0.24	A	2
K	Return-to-terminal ramp	25	2	2,020	455	0.23	A	2	574	0.28	B	2
L	On-ramp from Air Cargo Road	25	2	2,000	332	0.17	A	2	377	0.19	A	2
M	Northbound exit to South 170th Street	25	1	1,000	327	0.33	B	1	478	0.48	C	1
N	Southbound exit to South 170th Street	25	1	1,250	409	0.33	B	1	431	0.34	B	1
O	Air Cargo Road, southbound, north of South 160th Street	35	2	2,400	330	0.14	A *(d)*	2	345	0.14	A *(d)*	2
P	Air Cargo Road, northbound, north of South 160th Street	35	2	2,400	213	0.09	A *(d)*	2	271	0.11	A *(d)*	2
Q	Air Cargo Road, southbound, north of South 170th Street	35	1	1,200	185	0.15	A *(d)*	1	217	0.18	A *(d)*	1
R	Air Cargo Road, northbound, north of South 170th Street	35	1	1,200	74	0.06	A *(d)*	1	109	0.09	A *(d)*	1
S	Air Cargo Road, southbound, south of South 170th Street	35	1	1,200	--	0.00	A *(d)*	1	--	0.00	A *(d)*	1
T	Air Cargo Road, northbound, south of South 170th Street	35	1	1,200	--	0.00	A *(d)*	1	--	0.00	A *(d)*	1
U	Interim South Access, northbound	25	1	1,010	597	0.59	C *(d)*	1	--	--	--	--
V	Interim South Access, southbound	25	1	1,010	975	0.97	E *(d)*	2	--	--	--	--
U	South Airport Expressway, northbound	40	1	1,410	--	--	--	--	966	0.68	D *(d)*	2
V	South Airport Expressway, southbound	40	1	1,410	--	--	--	--	1,149	0.81	E *(d)*	2

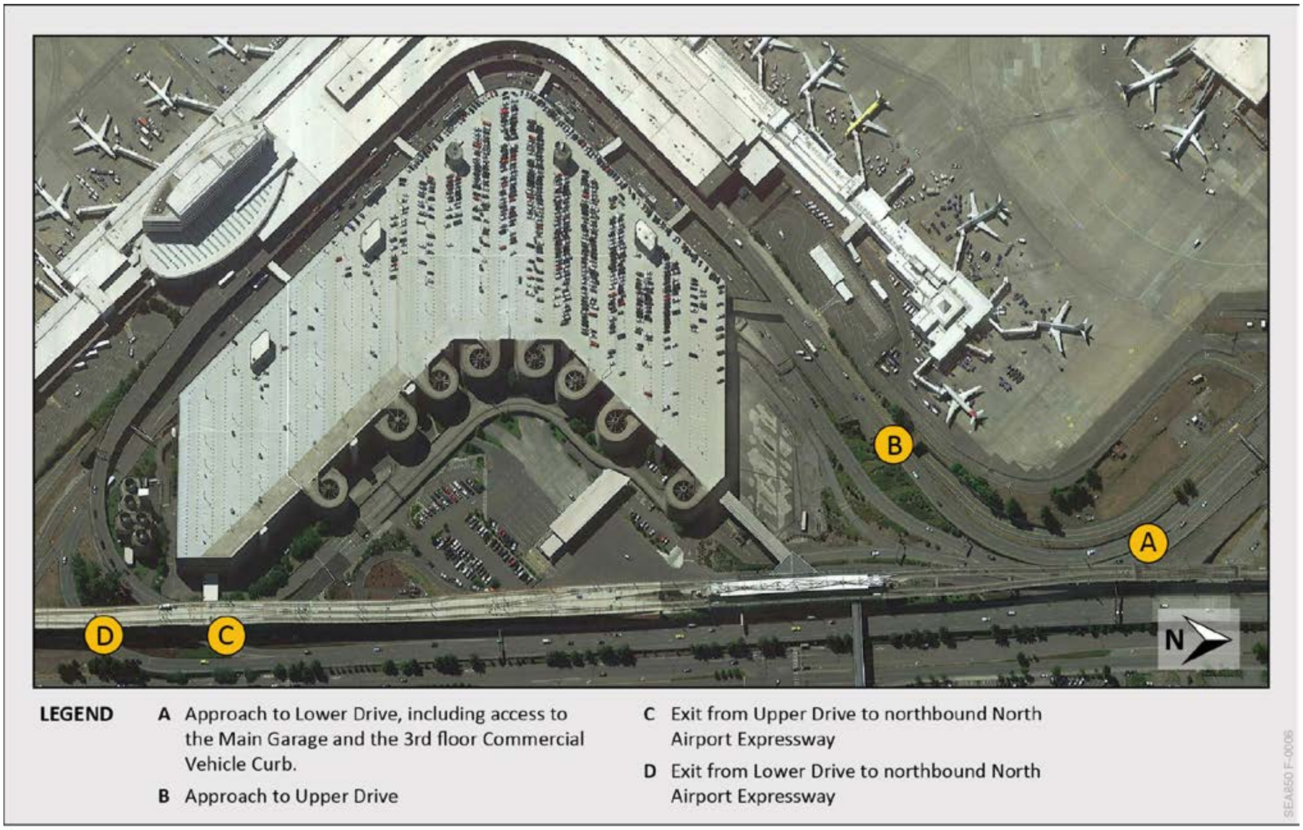
(a) See Table 4-8
(b) Based on volumes provided by the Port of Seattle.
(c) Based on Airport Cooperative Research Program (ACRP) Report 40, Table 4-1.
(d) Traffic conditions also impacted by intersections and/or truck turning movements.

Source: Inter*VISTAS*, from traffic volume data provided by the Port of Seattle, 2017.

4.4.3 *Terminal-area Circulation Roadways*

Figure 4-10 depicts four terminal-area circulation roadways identified as requiring additional capacity during the planning period.

Figure 4-10
Key Terminal-Area Roadways
Seattle-Tacoma International Airport



Source: Inter*VISTAS* Inc., 2016.

Table 4-10 summarizes the existing lane configuration, assumed capacity, and hourly volumes for the four selected terminal-area roadways assuming a one-terminal scenario. Table 4-11 summarizes the calculated volume/capacity ratio and corresponding level-of-service.

Table 4-10

Existing and Future Peak Hour Volumes, Selected Terminal-Area Roadways, One-Terminal Scenario

Seattle-Tacoma International Airport

	Number of lanes	Assumed capacity (vehicles per hour) *(a)*	Design hour volumes				
			2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
A. Approach to Lower Drive	2	2,500	2,110	2,640	2,830	3,220	3,610
B. Approach to Upper Drive	2	2,500	1,240	1,400	1,470	1,540	1,690
C. Exit from Upper Drive to North Airport Expressway	1	1,450	1,240	1,400	1,470	1,540	1,690
D. Exit from Lower Drive to North Airport Expressway	2	2,900	1,210	1,550	1,660	1,790	2,110

(a) Based on Airport Cooperative Research Program Report 40, Table 4-1.

Source: LeighFisher, 2015, from data provided by the Port of Seattle.

Table 4-11

Volume/Capacity Ratios and Corresponding Level of Service, Selected Terminal-Area Roadways, One-Terminal Scenario

Seattle-Tacoma International Airport

	2014		PAL 1		PAL 2		PAL 3		PAL 4	
	Volume/ capacity *(a)*	LOS	Volume/ capacity *(a)*	LOS	Volume/ capacity *(a)*	LOS	Volume/ capacity *(a)*	LOS	Volume/ capacity *(a)*	LOS
A. Approach to Lower Drive	0.84	E	1.06	F	1.13	F	1.29	F	1.44	F
B. Approach to Upper Drive	0.50	C	0.56	C	0.59	C	0.62	D	0.68	D
C. Exit from Upper Drive to North Airport Expressway	0.86	E	0.97	E	1.01	F	1.06	F	1.17	F
D. Exit from Lower Drive to North Airport Expressway	0.42	C	0.53	C	0.57	C	0.65	D	0.73	D

LOS = level of service

Note: LOS values are based on Airport Cooperative Research Program Report 40, Table 4-1.

(a) See Table for volume and capacity values.

Source: LeighFisher, 2015.

As shown in Table 4-11, the approaches to the Lower Drive and the exit from the Upper Drive operate at a poor LOS today and the LOS is expected to deteriorate in the future. The approaches to the Upper Drive and exit from the Lower Drive are expected to operate at LOS C through PAL 3 and at LOS D by

PAL 4. Table 4-12 summarizes the number of lanes required to achieve LOS C or better for each of the key roadway links.

Table 4-12
Lanes Required to Address Terminal-Area Roadway Deficiencies, One-Terminal Scenario
Seattle-Tacoma International Airport

		2014		PAL 1		PAL 2		PAL 3		PAL 4	
	Existing lanes	Baseline LOS *(a)*	Total lanes required for LOS C	Baseline LOS *(a)*	Total lanes required for LOS C	Baseline LOS *(a)*	Total lanes required for LOS C	Baseline LOS *(a)*	Total lanes required for LOS C	Baseline LOS *(a)*	Total lanes required for LOS C
A. Approach to Lower Drive	2	E	3	F	4	F	4	F	5 *(b)*	F	5 *(b)*
B. Approach to Upper Drive	2	C	2	C	2	C	2	D	3	D	3
C. Exit from Upper Drive to North Airport Expressway	1	E	2	E	2	F	2	F	2	F	2
D. Exit from Lower Drive to North Airport Expressway	2	C	2	C	2	C	2	D	3	D	3

LOS = level of service

(a) See Table 4-11.
(b) LOS D can be achieved with 4 total lanes.

Source: LeighFisher, 2015.

Table 4-13 summarizes the incremental number of lanes required on each of the four key roadways by each planning horizon.

Table 4-13
Terminal-Area Circulation Roadway Requirements
Seattle-Tacoma International Airport

Roadway segment *(a)*	Existing lanes	Period-over-period additional lanes required to achieve LOS C 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
A. Approach to Lower Drive	2	1	1	0	1 *(b)*	0 *(b)*
B. Approach to Upper Drive	2	0	0	0	1	0
C. Exit from Upper Drive to North Airport Expressway	1	1	0	0	0	0
D. Exit from Lower Drive to North Airport Expressway	2	0	0	0	1	1

LOS = level of service

(a) The locations for roadway segments are identified on Figure 4.
(b) LOS D can be achieved if no additional lane is provided in PAL 3.

Source: Inter*VISTAS* Inc., 2016.

Each roadway requires at least one additional lane prior to the end of the planning period. Though the approach to the Lower Drive requires a total of 5 lanes by PAL 3, there may be insufficient real estate to meet that requirement. In the event five lanes are infeasible, LOS D can be achieved through PAL 4 with a total of 4 lanes.

4.4.4 Curbside Roadways

This section summarizes the existing and future activity levels expected to use curbside facilities, curbside facility requirements, and alternatives for meeting the future activity levels at an acceptable level of service.

For planning purposes, curbside facility requirements are established to provide level-of-service (LOS) C or better during the 'design hour' identified for the facility. LOS C, as defined in *Airport Cooperative Research Program (ACRP) Report 40, Airport Curbside and Terminal Area Roadway Operations*, is based on (a) the curbside utilization, which indicates the ability of a roadway to accommodate existing or projected requirements for vehicles loading or unloading at the curbside by comparing the required length of loading or unloading area with the available curbside length and (b) the volume to capacity (v/c) ratio of the curbside roadway, with the poorest LOS of the two governing. Table 4-14 summarizes the curbside utilization ratio associated with LOS A through F. Additionally, because the curbside utilization value impacts the curbside roadway capacity value used in the v/c ratio, Table 4-14 also provides the assumed curbside roadway capacity associated with each curbside utilization LOS threshold.

Table 4-14
Curbside Utilization Level of Service Ratios

	Airport curbside levels of service					
	A	B	C	D	E	F
Curbside utilization ratio *(a)*	0.90	1.10	1.30	1.70	2.00	> 2.00
Curbside roadway capacity (vehicles per hour)						
Upper Drive (4 lanes)	2,830	2,790	2,680	2,220	1,800	Up to 1,800
Lower Drive (5 lanes)	3,400	3,280	3,100	2,710	2,400	Up to 2,400

(a) The ratio between the calculated curbside demand and the available effective curbside length.

Source: Airport Cooperative Research Program Report 40, Table 5-2.

Table 4-15 summarizes the v/c ratio associates with each curbside roadway LOS threshold.

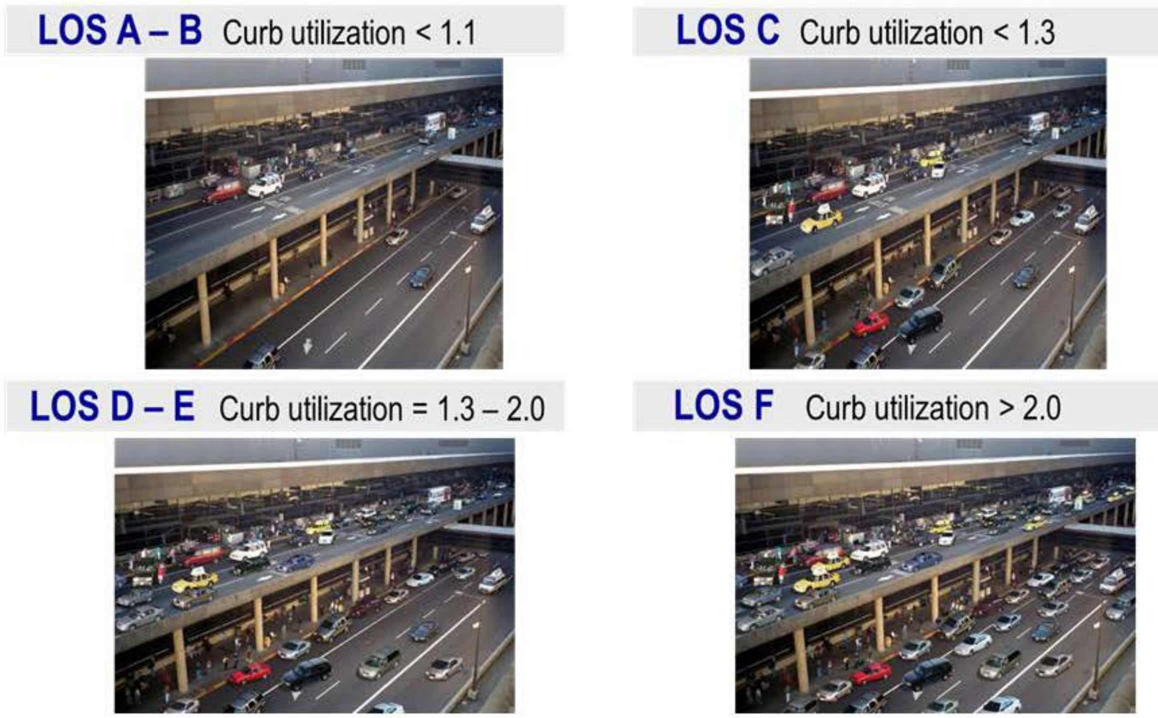
Table 4-15
Curbside Roadway Level of Service Ratios

	Airport curbside levels of service					
	A	B	C	D	E	F
Maximum through lane volume/capacity ratio	0.25	0.40	0.60	0.80	1.00	>1.00

Source: Airport Cooperative Research Program Report 40, Table 5-2.

Figure 4-11 depicts representative curbside conditions associated with each LOS.

Figure 4-11
Curbside Level of Service Depictions
Seattle-Tacoma International Airport



Source: Inter*VISTAS* Inc., 2016.

The goal of the curbside facility requirements is to identify, for each planning activity level, the number of loading and/or unloading vehicles requiring accommodation during the 'design hour' for each curbside. For curbsides where vehicles park in a linear fashion, such as at the Airport, curbside requirements are also typically provided in linear feet of curbside frontage parallel to a functioning terminal building and assume some amount of double-parking.

Key data used in developing the curbside requirements include:

- Design hour traffic volumes using Upper and Lower Level curbsides
- Vehicle classification distribution, as provided by 2009 surveys conducted by the Airport
- Peak period passenger volumes, as provided by the passenger flow model
- Average dwell times of vehicles stopping at the curb to pick up or drop off passengers
- Typical length of curb occupied by a stopped vehicle, by mode. This distance includes the vehicle length as well as distance in front and in back to allow for maneuvering as the vehicle exits or enters the traffic stream.

4.4.4.1 Methodology

Curbside facility requirements are calculated by one of two methods depending on the operating characteristics of the mode.

- **Vehicles operating on an on-demand basis** (e.g., private vehicles, taxicabs, for hire vehicles, selected courtesy shuttles, and 'other' vehicles such as delivery vans). Design hour vehicle volumes are combined with the assumed dwell times to determine the average number of vehicles simultaneously picking up and/or dropping off passengers. This average value is then adjusted to reflect the 95th percentile number of vehicles expected to simultaneously pick up and/or drop off passengers during the design hour. This 95th percentile value is then multiplied by the average vehicle length to estimate the length of occupied linear curb, which is then divided by 1.3 to account for a level of double-parking consistent with industry standards for level-of-service C for curbside roadways.

- **Vehicles operating on a scheduled basis** (e.g., airporters, rental car shuttles, selected courtesy shuttles, and public transit). Consistent with current operations, these vehicles are assumed to require dedicated space on the curbside. For each curbside zone, vehicle volumes are combined with the assumed dwell times to determine the average number of vehicles simultaneously picking up and/or dropping off passengers. Due to the scheduled nature of these vehicles, there is a low likelihood of peaking within the hour. Thus, requirements reflect the average number of vehicles expected to be loading and/or unloading simultaneously.

4.4.4.2 Dwell Times and Vehicle Lengths

Table 4-15 summarizes the dwell times and vehicle lengths assumed for each mode. The dwell time values are based on typical values suggested in *ACRP Report 40* as well as values used in prior curbside analyses at the Airport. These values, however, are not necessarily representative of existing conditions and current dwell times are understood to exceed the values shown on Table 4-16. However, since curbside dwell times are directly related to the Airport's practices regarding enforcement of curbside policies, it is assumed for planning purposes that the values shown in Table 4-16 can be achieved. The vehicle lengths are those typically used in the industry and represent the distance between the front of a vehicle and the front of the vehicle immediately in front or behind. The future curbside requirements assume that these values remain unchanged through the planning period.

Table 4-16
Curbside Vehicle Dwell Times and Lengths
Seattle-Tacoma International Airport

	Dwell time (minutes)		
	Passenger drop-off	Passenger pickup	Vehicle length (feet)
Private vehicles *(a)*	2.0	2.0	25
Taxicabs *(b)*	2.0	n/a	25
Limousines *(b)*	2.0	n/a	25
Shared ride vans *(b)*	2.5	4.0	30
Scheduled buses / vans (airporters) *(c)*	5.0	n/a	Up to 60
Rental car shuttle *(d)*	4.0	4.0	60
Public transit	2.0		60
Other (service vehicle, police car, etc.)	3.0	3.0	30

(a) Includes rental cars using the curbsides.
(b) Vehicle picks up passengers in the commercial vehicle lanes in the Main Garage.
(c) Depending on vehicle size, vehicle picks up passengers in the commercial vehicle lanes in the Main Garage or in the South Ground Transportation Lot.
(d) Vehicle picks up and drops off passengers on the Lower Level.

Source: LeighFisher, August 2015.

4.4.4.3 Vehicle Classification

Table 4-17 presents the assumed vehicle classification percentages for vehicles dropping off enplaning passengers on the Upper Drive, based on visual surveys conducted as part of previous curbside planning efforts.

Table 4-17
Curbside Vehicle Classification, Upper Drive
Seattle-Tacoma International Airport

	Share of vehicles using roadway
Private vehicles	77%
Taxicabs	11
Limousines	8
Shared ride vans	2
Scheduled vans/buses (Airporters)	1
Charter buses	< 1
Other vehicles	1
Total	100%

Source: LeighFisher, based on traffic surveys conducted in October 2009 during morning and midday peak periods.

On the Lower Drive, vehicles using the curbsides are limited to private vehicles, the consolidated rental car shuttle, and public transit buses. Given that the rental car shuttle and public transit buses operate on fixed schedules with known hourly volumes, vehicle classification surveys were not conducted.

4.4.4.4 Design Hour Volumes

Table 4-18 and Table 4-19 summarize the design hour curbside volumes for the Upper Drive and Lower Drive, respectively, for baseline (2014) conditions through PAL 4. These volumes are based on (a) 2014 traffic counts conducted in August and September 2014 and (b) vehicle classifications provided in Table 4-17. Volumes are escalated in direct proportion to expected growth in peak period passengers during the Airport's peak month. As such, the Upper Drive peak, which is predominately linked to enplaning passenger volumes and occurs in the early morning, is assumed to grow at the same rate as the peak 60-minute period for enplaning passengers departing between 6 a.m. and 9 a.m.: a growth factor of 1.42 from 2014 to PAL 4. The Lower Drive peak, which is predominately linked to deplaning passenger volumes and occurs in the middle of the day, is assumed to grow at the same rate as the peak 60-minute period for deplaning passengers arriving between 11 a.m. and 2 p.m.: a growth factor of 1.62 from 2014 to PAL 4.

Table 4-18
Upper Drive Curbside Volumes
Seattle-Tacoma International Airport

	Base year (2014)	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Private vehicles	953	1,077	1,149	1,218	1,352
Taxicabs	140	159	169	180	199
Limousines	96	109	116	123	136
Shared ride vans	22	25	27	29	32
Scheduled vans/buses (Airporters)	13	13	13	13	13
Charter buses	2	2	2	2	2
Other vehicles	14	16	17	18	19
Total	1,240	1,401	1,493	1,583	1,753

Source: Inter*VISTAS*, October 2016.

Table 4-19
Lower Drive Curbside Volumes
Seattle-Tacoma International Airport

	Base year 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Private vehicles	1,104	1,487	1,611	1,671	1,785
Rental car shuttle	138 *(a)*	167	193	219	245
Public transit	8 *(b)*	8	8	8	8
Total	1,250	1,662	1,812	1,898	2,038

(a) Based on schedule required for 2,000 passengers per hour (55 second headways).
(b) Assumes 3 routes operating in two directions at 10-minute headways.

Source: Inter*VISTAS*, October 2016.

4.4.4.5 Curbside Requirements

Curbside requirements are based on the curbside roadway level of service (LOS), which provides an overall indication of the quality of the experience of drivers and passengers using the curbside roadway. The primary element defining the LOS at an airport curbside roadway is the ability of a motorist to enter and exit the curbside space of their choice (e.g., one near their airline door or other chosen destination). As roadway demands and congestion increase, motorists are required to stop in spaces further away from their preferred destination. This requires the motorist to either stop in a downstream curbside space, double-park, or in an extreme case, circle past the curbside area multiple times while searching for an empty space.

The key measures defining the LOS of a curbside roadway are (a) the number of vehicles parked or stopped in the curbside lane, and the percent that are double-parked, triple-parked, or otherwise stopped in a position that interferes with the flow of traffic in adjacent lanes and (b) the volume-to-capacity ratio (v/c) of the total vehicles using the roadway. These measures are a function of the curbside demand versus the available capacity.

Level of service "C" is desirable for design of a new facility or for an existing facility at medium-hub airports, recognizing that during peak hours and days of the year the level of service may fall to "D" or poorer. Level of service on curbside roadways is estimated separately for through traffic and for curbside loading/unloading traffic, but the overall LOS is governed by the poorer of the two components.

Table 4-20 summarizes the curbside facility requirements for the Main Terminal for Baseline (2014) through PAL 4. These requirements reflect the volumes presented in Table 4-18 and Table 4-19, the dwell times and vehicle lengths presented in Table 5-16, and an assumption that demand is uniformly distributed along the curbside length. In practice, dwell times have traditionally been longer and curbside demand has been concentrated in front of major air carriers (i.e., Alaska Airlines). However, dwell times and distribution along the curb can be addressed in whole or in part through increased curbside enforcement and other operational strategies intended to improve the distribution of demand along the curbside.

Table 4-20
Curbside Requirements
Seattle-Tacoma International Airport

	Required curbside length (linear feet)						Required number of total roadway lanes (assuming required curbside length is provided)					
	Existing capacity	2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 42034	Existing lanes	2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Upper Drive	1,200	1,070	1,180	1,260	1,320	1,460	4	4	4	4	4	5
Lower Drive												
Unallocated curb	1,050	960	1,250	1,350	1,390	1,480	-	-	-	-	-	-
Rental car shuttles	360	480	600	720	780	900	-	-	-	-	-	-
Public transit	120	120	120	120	120	120	-	-	-	-	-	-
Total	1,530	1,560	1,970	2,190	2,290	2,500	5	4	5	5	6 *(a)*	6 *(a)*

LOS = level of service

(a) LOS D can be achieved with 5 lanes.

Source: Inter*VISTAS* Inc., 2016.

4.4.5 *Commercial Vehicle Facilities*

Currently, commercial vehicles pick up in two areas of the Airport: the 3rd floor of the Main Garage and the South Ground Transportation Lot. In general, the 3rd floor of the Main Garage serves the on-demand modes (such as taxicabs and limousines) and courtesy vehicles (which, during peak periods, typically operate on a schedule). The South Ground Transportation Lot predominately serves charter buses and scheduled van and bus services (airporters).

4.4.5.1 Methodology

Commercial vehicle facility requirements are calculated by one of two methods depending on the operating characteristics of the mode. In general, each discrete mode requires dedicated loading spaces to ensure customers can easily find their desired transportation mode.

- **Vehicles operating on an on-demand basis** (e.g., taxicabs, limousines, shared-ride vans). Design hour vehicle volumes are combined with the assumed dwell times to determine the average number of vehicles simultaneously picking up passengers. This average value is then adjusted to reflect the 95th percentile number of vehicles expected to simultaneously pick up passengers during the design hour for that mode, which indicates the number of discrete loading positions required for that mode.

- **Vehicles operating on a scheduled basis** (e.g., airporters, rental car shuttles, courtesy shuttles, and public transit). For each mode, vehicle volumes are combined with the assumed dwell times to determine the average number of vehicles simultaneously picking up passengers. Due to the scheduled nature of these vehicles, there is a low likelihood of peaking within the hour. Thus, requirements reflect the average number of vehicles expected to be loading and/or unloading simultaneously.

4.4.5.2 Dwell Times

Table 4-21 summarizes the dwell times assumed for each mode. The dwell time values are based on typical values suggested in *ACRP Report 40* as well as values used in prior curbside analyses at the Airport and reflect the time required for *active* loading of a vehicle during a typical busy period of the day. During less busy periods, on-demand modes (such as taxicabs) that are expected to wait for customers typically have dwell times exceeding the active loading time, but these longer dwell times should not be used to estimate facility requirements.

Table 4-21
Commercial Vehicle Loading Times
Seattle-Tacoma International Airport

	Active loading time (minutes)
Taxicabs	1.0
On-call limousines	2.0
Pre-arranged limousines *(a)*	60
Shared ride vans	4.0
Transportation Network Companies	*[to come]*
Scheduled buses / vans (airporters)	15.0
Rental car shuttle	3.5
Public transit	2.0

(a) Provides time for driver to meet customer inside the terminal.

Source: Inter*VISTAS*, October 2016.

4.4.5.2 Design Hour Volumes

Table 4-22 summarizes the design hour volumes for each commercial vehicle mode. These volumes are based on (a) 2014 traffic counts conducted in August and September 2014 and (b) vehicle classifications provided in Table 4-17. Volumes are escalated in direct proportion to expected growth in peak period passengers during the Airport's peak month. Commercial vehicle volumes, which are predominately linked to deplaning passenger volumes, which peaks in the middle of the day, are assumed to grow at the same rate as the peak 60-minute period for deplaning passengers arriving between 11 a.m. and 2 p.m.: a growth factor of 1.62 from 2014 to PAL 4.

Table 4-22
Commercial Vehicle Pickup Volumes
Seattle-Tacoma International Airport

	Base year (2014)	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
3rd Floor of the Main Garage					
Taxicabs	291	387	405	438	492
On-call limousines	11	14	15	16	18
Shared-ride vans	18	24	25	27	30
Pre-arranged limousines	5	6	6	7	8
Transportation Network Companies *(a)*					
Courtesy vehicles *(b)*	178	190	123	197	215
Crew vans	12	16	17	18	21
Downtown shuttle *(c)*	2	2	2	2	2
South Ground Transportation Lot					
Scheduled airporters *(d)*	8	8	8	8	8
Charter buses – drop-off *(e)*	30	40	44	45	49
Charter buses – pickup *(e)*	30	40	44	45	49

(a) To come.
(b) Includes courtesy vehicles operated by hotels, motels, and off-Airport parking operators. Volume growth reflects estimated increase in the number of operators, not increase in passenger activity.
(c) Scheduled service (two trips per hour).
(d) Scheduled services. Peak hour volumes would increase based on introduction of new operators or increased frequencies. To increase capacity, most existing operators could choose to operate larger vehicles rather than increase the number of trips.
(e) Charter bus peak volumes reflect cruise ship charter bus activity during summer months. Volumes are based predominately on number of cruise ships (and boat capacity) using downtown Seattle piers. Absent cruise ship forecasts, demand is assumed to increase at similar rate as midday arriving passengers.

Source: Inter*VISTAS*, October 2016.

4.4.5.3 Loading Requirements

Table 4-23 summarizes the number of required loading spaces for commercial ground transportation. For taxicabs, on-call limousines, shared-ride vans, and pre-arranged limousines, loading requirements reflect the number of loading spaces needed to accommodate demand during peak periods within the peak hour. For courtesy vehicles, requirements reflect predominately scheduled operations (which are less likely to peak within the peak hour) and two stops along the courtesy van islands. Requirements for scheduled airporters provide an allowance for one additional stall during the planning period, but that is provided only as a reserve in the event a new route is introduced and/or existing operators choose to add departures during the peak hour. Charter bus drop-off requirements reflect the number of loading spaces needed to accommodate demand during peak periods within the peak hour while charter bus pickup requirements assume minimal peaking due to use of access control that meters arrivals of vehicles into the pickup area.

In addition, taxicab operations require a close-proximity feeder queue from which vehicles can rapidly fill loading spaces once they are vacated. Requirements assume this area is sized to provide a 10-minute supply of taxicabs, which is approximately the length of time required to travel from the remote hold lot to the loading areas during congested roadway conditions.

Table 4-23
Commercial Vehicle Loading Area Requirements
Seattle-Tacoma International Airport

	Existing capacity (spaces)	Requirements (spaces)				
		2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
3rd Floor of the Main Garage						
Taxicabs	13	9	11	11	12	13
Taxicab feeder queue	70	48	64	68	73	82
On-call limousines	2	1	2	2	2	2
Shared ride vans	8	3	4	4	4	4
Pre-arranged limousines	48	8	10	11	11	12
Transportation Network Companies *(a)*						
Courtesy vehicles	22 *(b)*	20	22	22	22	24
Downtown shuttle		1	1	1	1	1
Airline crew vans		2	2	3	3	3
South Ground Transportation Lot						
Scheduled airporters *(c)*	2 *(d)*	2	2	2	3	3
Charter buses – drop-off *(e)*	20 *(d)*	8	11	12	12	13
Charter buses – pickup *(e)*		6	8	9	9	10

(a) To come.
(b) These spaces serve courtesy vehicle, the Downtown shuttle, and airline crew vans.
(c) Requirements reflect number of operators and scheduled frequency. Future requirements provide an allowance for one additional loading area through the planning period.
(d) South Ground Transportation Lot may be fully displaced by construction of the International Arrivals Facility. Charter bus spaces serve both pickup and drop-off activity.
(e) Space requirements reflect requirements during peak periods for summer cruise ship charter bus activity.

Source: LeighFisher, *Technical Memorandum No. 5 Facility Requirements and Alternatives*; Inter*VISTAS* Inc., 2016; LeighFisher, *IAF Requirements.*

4.4.5.3 Remote Hold Facilities

Taxicabs, transportation network companies, airporters, and charter buses typically use a remote hold lot to wait until they are dispatched to the Main Terminal or just prior to their scheduled pickup time. Table 4-24 summarizes information provided by the Port of Seattle regarding hold facility capacity available in 2016 and required by PAL 4.

Table 4-24
Commercial Vehicle Hold Lot Requirements
Seattle-Tacoma International Airport

	Existing capacity (spaces)	PAL 4 requirement
Taxicabs	98	190
Transportation Network Companies	43	80
Scheduled airporters	9	14
Charter buses	18	30

Source: Port of Seattle, June 2016.

4.4.6 Public Transit Facilities

As described in Section 4.4.3.5, public transit bus services are expected to require a total of two parking positions through PAL 4, specifically, 120 linear feet if parked on a curbside.

Requirements for public transit facilities at the Airport are predominantly driven by (a) the number of individual services and/or routes serving the Airport and (b) the functional requirements of the service. Currently, transit services at the Airport include the Sound Transit light rail service and two bus routes operated by Sound Transit. As demand for the light rail service increases, it was assumed that more passengers would board each train and/or that Sound Transit would increase the frequency of trains serving the Airport.

Public transit requirements assume no change in the number of transit bus routes operating from the Airport, frequency of service during peak periods, and dwell times. In the event a new transit bus operator begins service at the Airport, the Port will attempt to accommodate the vehicles within the loading areas currently used by the Sound Transit bus services.

4.4.7 Public Parking

The methodology used to establish public parking requirements is similar to that for identifying existing requirements, as described in Section 4.3.6.

4.4.7.1 Key Assumptions

Preliminary future requirements assume:

- Passenger propensity to park (i.e., transactions per passenger) would not change through the planning period. This assumption implies the share of airline passengers choosing to park versus use other access modes (i.e., private vehicles at curbside, taxicabs, airporters, public transit) during periods associated with peak parking demand will be substantially unchanged through the planning period.

- Future parking demand will increase at the same rate as planning day passengers, as opposed to peak hour or annual passenger volumes. This assumption, which is commonly used as part of airport master plans and other long-range airport parking demand studies, reflects that parking space demand is predominately generated by airline passengers parking for long durations and therefore is the result of the accumulation of vehicles over multiple days (as opposed to activity generated by a peak hour). Furthermore, because almost all parking transactions are for 14 days or less, parking demand is more likely to mirror monthly or weekly passenger volumes than annual volumes.

- The Airport will be able to change the share of the overall long-duration parking demand accommodated in on-Airport parking facilities. Even though off-Airport operators typically adjust their prices based on changes in the price of the Main Garage and (to a lesser extent) the Doug Fox Lot, the Airport has the ability to increase or decrease its share of the long-duration parking market by changing its prices and/or services provided.

- To calculate requirements, future demand (i.e., design day vehicle accumulation) is increased by a 10% circulation factor to address a customer's difficulty in locating available spaces in a large, full parking facility; improperly parked vehicles; out-of-service spaces (i.e., for maintenance); and other factors.

4.4.7.2 Future Demands

Using the baseline demand described in Section 4.3.6 and other key assumptions, future public parking facility requirements were calculated as shown in Table 4-25. The Main Garage and Doug Fox Lot have sufficient capacity to continue to meet demand through PAL 4. Off-Airport facilities, however, will need to increase capacity (or reduce their share of the market). Table 4-25 also shows that of the spaces served in the Main Garage and the Doug Fox Lot, approximately 87% are located in the Main Garage (which can be considered 'close-in' parking).

Table 4-25
Public Parking Facility Requirements *(a)*
Seattle-Tacoma International Airport

	Existing 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Close-in parking (Main Garage) *(b)*	12,800	9,260	10,440	11,590	12,740
Remote (Doug Fox Lot)	1,620	1,090	1,230	1,360	1,500
Off-Airport facilities	18,500	20,400	23,000	25,500	28,000
Total	32,920	30,750	34,670	38,450	42,240

4.4.8 *Employee Parking*

Employee parking requirements, shown in Table 4-26, were estimated based on both forecast passenger and air cargo activity. Key assumptions related to the employee parking estimates include the following:

- The forecast number of employees using the employee parking facilities is based upon current commuting trends and assuming a modest shift of 5% of the employees to alternative modes including commuter rail, light rail, public transit, carpools, vanpools, and non-motorized modes.
- The number of passenger terminal employees was forecast based upon forecast passenger growth. The passenger terminal employee group includes employees of the airlines, the ADR program, Port of Seattle, federal agencies, and other airport related services. It was also assumed that 16% of the parking demand was met with parking stalls provided in the Main Terminal and North Terminal parking garages.
- Seattle-Tacoma International Airport Landside Operations staff have determined that to meet customer service goals they will manage the employee parking facilities to 90% occupancy. Based upon current activity levels this corresponds with 2.5 access cards per stall. The number of future parking stalls required was calculated based upon this ratio.

Table 4-26
Employee Parking Requirements
Seattle-Tacoma International Airport

Description	Existing	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Passenger terminal					
Employees *(a)*	11,656	12,300	13,800	15,600	17,200
Employee parking stalls *(b)*					
Remote parking	4,056	4,160	4,670	5,270	5,870
Terminal garage	754	740	830	930	1,030
Subtotal	4,810	4,900	5,500	6,200	6,900
Air cargo and aircraft maintenance facilities					
Air cargo buildings (sf) *(c)*	550,000	501,000	876,000	1,320,700	1,275,000
Aircraft maintenance buildings	346,000	346,000	346,000	324,000	324,000
Remote employee parking stalls *(d) (e)*	66	70	70	590	750
On-site employee parking stalls *(d) (e)*	1,271	1,280	1,810	1,720	1,490
Total Employee Parking Stalls – Port Facilities					
Remote parking	4,122	4,230	4,740	5.860	6,620
Terminal garage	754	740	830	930	1,030
Subtotal	4,876	4,970	5,570	6,790	7,650

(a) Employee parking forecast based upon SAMP passenger forecasts and 5% reduction for alternative modes.
(b) Assumed one stall per 2.5 employees and 85% in remote parking.
(c) Includes allowance for off-site facilities.
(d) Calculated employee parking needs at 1.4 parking stalls per 1,000 sf of building.
(e) Assumed parking remain on-site (existing condition) until facilities are redeveloped then 50% on-site/50% remote.

Source: Port of Seattle, October 2016.

- The number of cargo employee parking stalls was calculated based upon the facilities anticipated to support the cargo functions. We assumed:
  - Initially, cargo facilities will be expanded off-site; off-site facilities will be sized to accommodate employee parking needs.
  - The existing central cargo facilities (e.g., Swissport) will likely be displaced by passenger-related development and that the north cargo (e.g., Transiplex) facilities will be redeveloped in order to maximize the site for air cargo functions. Thus, 50% of the employee parking needs must being accommodated off-site.
  - If the South Aviation Support Area (SASA) is developed to support cargo functions, then that site would be maximized for aircraft and cargo functions, resulting in 50% of the employee parking needs being accommodated off-site.
  - The overall requirement is for 1.4 parking stalls per 1,000 SF of cargo building.
- The number of aircraft maintenance employee parking stalls was calculated based upon the facilities anticipated to support the aircraft maintenance functions. We assumed that if the existing aircraft maintenance facilities are relocated to a different on-Airport location, then 50% of the employee parking needs must be accommodated off-site. The overall forecast assumes 1.4 parking stalls per 1,000 SF of building.

4.4.9 Rental Car Facilities

For planning purposes, it is assumed that the total area required for rental car facilities when the Airport serves 66 MAP can be calculated by assuming proportional growth with annual passengers. Thus, by 66 MAP, the existing RCF will need to grow by approximately 15.8%, which equates to an additional 270,000 square feet.

4.4.10 Non-motorized Access

Options for pedestrians and bicyclists to access the Airport terminal are limited. The requirement is to ensure that advanced planning and design related to future landside facilities consider maintaining and improving access to the existing terminal as well as connectivity to any future terminals.

4.4.11 Long-Term Operations

Cruise ship passengers are an important and growing source of airport passenger activity. Over one million cruise ship passengers are expected on the Seattle waterfront in 2017. A small percentage of cruise passengers also arrive from, and depart to, the Vancouver, BC waterfront.

Mid- and long-term solutions for cruise ship facilities at the airport will be developed by the Advanced Planning Team following completion of the SAMP. These solutions will be planned to accommodate phased implementation of roadways and terminal expansion. Airport and Seaport Operations will also continue to develop and refine strategies for shifting check-in activities away from the airport, although there is limited space at both the airport and waterfront for these facilities. The Port is currently trying a pilot program to provide free bag service as a strategy to deal with the limited space.

Air Cargo

This chapter presents assessments of existing air cargo facilities and summarizes the requirements that must be satisfied to accommodate the aviation activity forecast through the 20-year planning period.

5.1 Introduction

The Port Commission's Century Agenda strategic goal, adopted in January 2012, is to position the Puget Sound region as a premier international logistics hub with the objective to triple 2013 annual air cargo volume to 750,000 metric tons by 2037. This section summarizes the facility requirements for accommodating the volume of air cargo specified by the Century Agenda as well as the volume of air cargo forecast for PALs 1 through 4. The Century agenda air cargo volume exceeds the forecast air cargo activity by approximately 40%.

The scope of the air cargo requirements analyses related to on-Airport facilities and operations and included (1) identifying existing air cargo freighter hardstands and air freight, integrator freight, and airmail warehouse facilities, current tenants, and the cargo volumes able to be accommodated, (2) assessing key issues and limitations related to the existing cargo facilities, including those related to the ramps, warehouses, and landside areas (3) gathering appropriate benchmark data, (4) recognizing key dimensional criteria and necessary functional relationships (e.g., the proximity of freighter hardstands to cargo warehouses), and (5) discussing with operations staff how the Airport's cargo facilities are likely to be operated in the future.

Air cargo requirements were prepared and evaluated using a collaborative approach which involved cargo operators, tenants, and Port planning and operations staff. A key assumption was that all air cargo activity currently accommodated will remain at the Airport through the 20-year planning period.

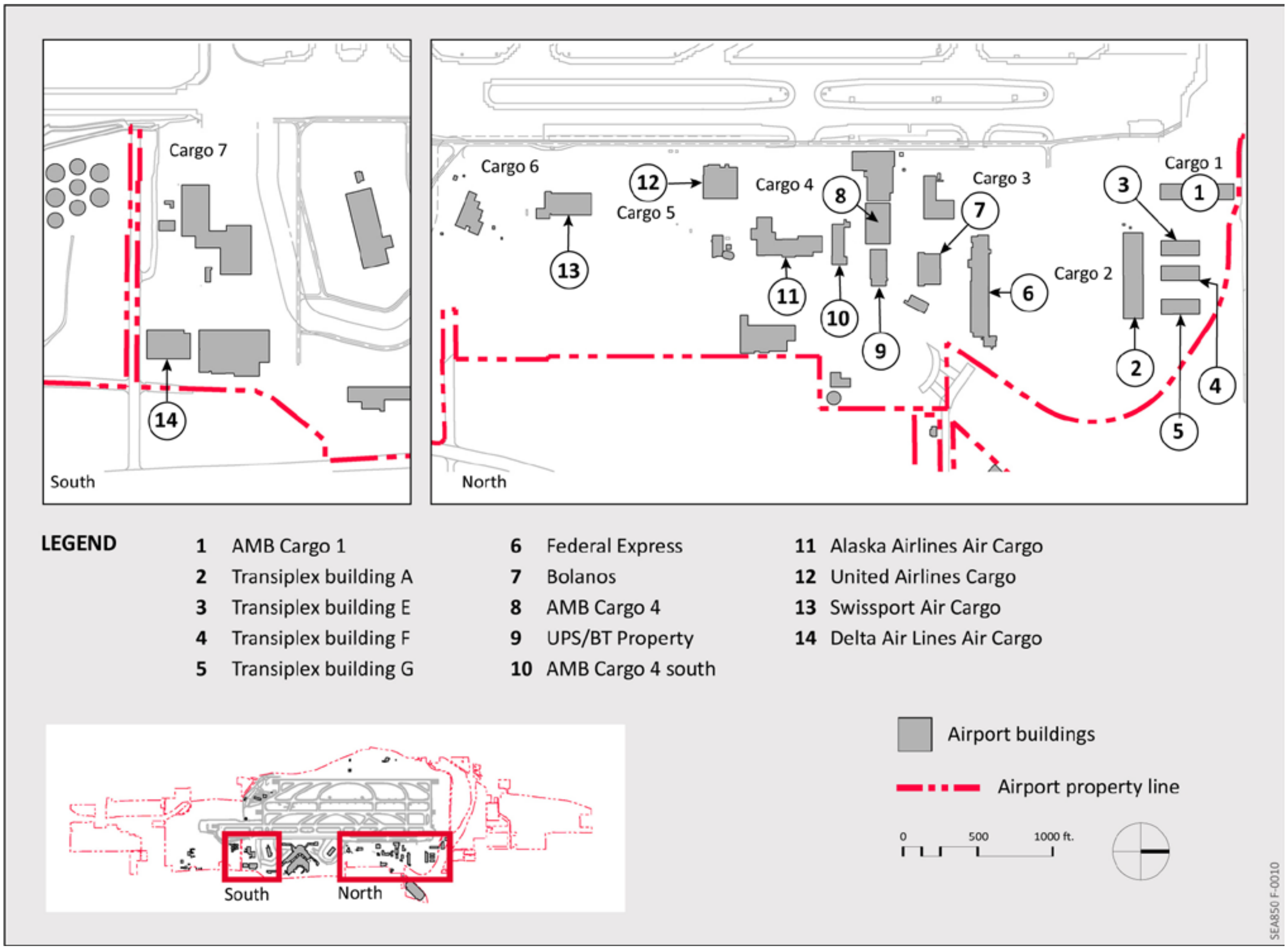
5.2 Existing Air Cargo Facilities and Operations

The locations of air cargo warehouse facilities and ramp areas are shown on Figure 5-1. The space utilized for air cargo in each of the cargo facilities identified in Figure 51 is summarized in Figure 5-2. Existing air cargo facilities are typically small, inefficient, and accommodate various cargo volumes.

There are 17 aircraft hardstands at the Airport that are currently used to accommodate cargo aircraft; other hardstands could accommodate cargo aircraft if necessary. The aircraft hardstands are located in eight areas, Cargo 1 through Cargo 7 and Alaska Airlines Air Cargo, as shown in Figure 51.

With the exception of FedEx (Building #7), warehouses at the Airport do not employ a high level of mechanization or sophisticated cargo storage & handling systems. Instead their operations rely on simple forklifts, dollies, and tugs; at most warehouses, cargo is stored directly on the floor for processing and storage during its short dwell time.

Figure 5-1
Existing Air Cargo Warehouse Locations
Seattle-Tacoma International Airport



Source: Logplan, 2016.

Current issues at cargo facilities are more attributable to layout-related congestion than to actual capacity deficits. This congestion is exacerbated by activity generated by non-cargo operations, such as the Port's aviation maintenance facility, flight kitchen, and United Airlines maintenance operations interspersed within the cargo campus.

The nature of the commercial relationships between the Airport and its cargo tenants constrains the Airport's ability to impose a strict cargo-oriented policy. Tenants are free to sub-lease Airport property originally designated for cargo to non-cargo users, and the Airport has little ability to control such behavior. Additionally, in contrast with business arrangements at other international airports, Airport staff is not involved in determining or mandating service levels and standards. The result is an assortment of relatively small warehouses, each operating individually as best suits its own interests, and the less than optimum utilization of the relatively large area currently allocated to cargo operations.

Table 5-1
Summary of Air Cargo Warehouse Tenants, Areas, and Utilizations
Seattle-Tacoma International Airport

Tenant (Building #)	2013 Cargo volume (metric tons)	Warehouse (sq. ft.)	Space utilized (sq. ft.)	Utilization (tons/sq. ft. /yr.)
Single Tenant				
FedEx (#6)	102,642	73,250	73,250	1.40
Southwest (#10)	4,838	25,700	11,000	0.44
Alaska Airlines (#11)	28,125	68,730	68,730	0.41
Delta Air Lines (#14)	31,478	58,000	58,000	0.54
Cargo Handling Company				
Hanjin (#2)	16,511	84,000	23,600	0.70
CAS (#8)	29,771	48,520	48,520	0.61
Swissport (#13)	40,864	31,560	31,560	1.57
WFS – Transiplex E (#3)	2,866	25,000	unknown	unknown
Other Cargo Facilities				
Transiplex G – USPS – Matheson (#5)	unknown	25,000	25,000	unknown
FedEx Heavy Freight & Matheson (#1)	31,989	51,720	15,000	2.13
Building #12	Vacant	49,260	--	n/a
Total		540,740	354,660	

Sources: Port of Seattle, Webber Air Cargo, and Logplan LLC, May 2014.

5.3 Desired Air Cargo Campus Characteristics and Planning Assumptions

5.3.1 Warehouse Locations

Airport facilities that accommodate belly cargo and freighter cargo, which are cargo accommodated in the cargo compartments of passenger aircrafts and in freighter aircrafts, respectively, should be located to minimize the transfer time of cargo between the aircrafts and the warehouses. Such transfers typically involve using tugs and dollies traveling on the Airport's vehicle service roads. Therefore, warehouses accommodating belly cargo should be as close as possible to passenger aircraft gates and warehouses accommodating freighter cargo should be as close as possible to the freighter hardstands.

Cargo warehouses should be located to (1) facilitate access to both landside facilities (i.e., the Airport and regional roadway system) and airside facilities (i.e., taxiways and runways), (2) provide adequate airside space to accommodate freighter aircraft parking positions, ground service equipment and unit load device storage and operating space, and (3) provide adequate landside space to facilitate shipping, receiving, and customer access functions.

A single location for air cargo facilities is preferable to multiple locations to (1) reduce truck traffic on the Airport access roadway system, (2) reduce vehicle emissions, and (3) improve customer service.

Assuming that airmail continues to be contracted mainly to FedEx (or a new entrant integrated carrier), the preferred location for any replacement airmail facility would be adjacent to (or integrated with) the integrated carrier facility.

5.3.1.1 Warehouse Utilization

Cargo warehouse utilization is measured by the metric cargo tons per square foot per year. There is considerable variability in the utilization rates in air cargo facilities, depending on a number of factors such as the type of cargo facility (e.g., air freight, integrator, or airmail), level of mechanization and automation, airport size, extent of hubbing and transshipment cargo, characteristics of the cargo and cargo operators, and dwell time.

Benchmarking analyses performed by LeighFisher indicate the following.

- Facilities at large airports with a high percentage of transshipment cargo, such as facilities at Incheon, Dubai, Abu-Dhabi, Shanghai Pudong, and Tokyo Narita international airports, achieve utilization rates of 1.5 - 2.5 ton per square foot per year.
- Facilities at other large airports with less transshipment cargo, such as facilities at Hong Kong, Kansai, Singapore, and Bangkok international airports achieve utilization rates of 1 - 1.5 ton per square foot per year.

All these airports are equipped with modern mechanized and automated storage and handling systems to handle over 1 million tons of cargo per year. In contrast to these modern facilities, some older facilities experience long dwell times due to outdated customs and security procedures. As a result, their utilization rates are approximately 0.65 ton per square foot per year.

Utilization rates at most U.S. airports are estimated at 0.5 -1.0 tons per square foot per year.

5.3.1.2 Potential Long-Term Utilization Rates at the Airport

- **Air freight:** If the Airport's current system of multiple, decentralized, multiple operator warehouses continue, it is assumed that the average utilization rate can be improved up to 0.7 tons per square foot per year by improving manual equipment and handling techniques.
- **Integrator Freight:** In the absence of specific information regarding the operation of other integrators at the Airport, it has been assumed that (1) future utilization will be based on FedEx's existing facility utilization of 1.84 tons per square foot per year, (2) FedEx's existing facility will reach capacity at 2018, at which it will reach utilization of about 2.0 tons per square foot per year, and (3) a utilization of 1.5 tons per square foot per year will be used to estimate requirements for all future integrator freight facilities.
- **Airmail:** Airmail volume has decreased significantly, as the internet has replaced postal services over the past 10 years. This trend is expected to continue and airmail will remain marginal at most airports, including SEA. It is assumed that the current utilization of

approximately 1.0 tons per square foot per year should be used for future planning purposes.

5.3.1.3 Air Freight Warehouse Operating Concepts (Business Models)

Air freight warehouse operating Concept #1 refers to multiple warehouses, multiple operators, single- and multiple-tenants, and non-mechanized facilities and reflects the existing facilities and business arrangements at the Airport. With some improvements in operating methods, it is believed the long-term utilization of air freight warehouses under this operating concept could be improved to 0.7 tons per square feet annually.

Air freight warehouse operating Concept #2 refers to a limited number of warehouses and operators with multiple users and mechanized facilities. The long-term utilization of air freight warehouses under this operating concept is expected to be approximately 1 ton per square foot per annually. Implementation of this operating concept would require significant changes in business practices at the Airport.

Given the Airport's limited land area, it is believed that cargo productivity must increase. However, the adoption of a business model incorporating large mechanized and automated multi user air freight warehouses, possibly employing multi-level cargo processing is not believed to be feasible at the Airport.

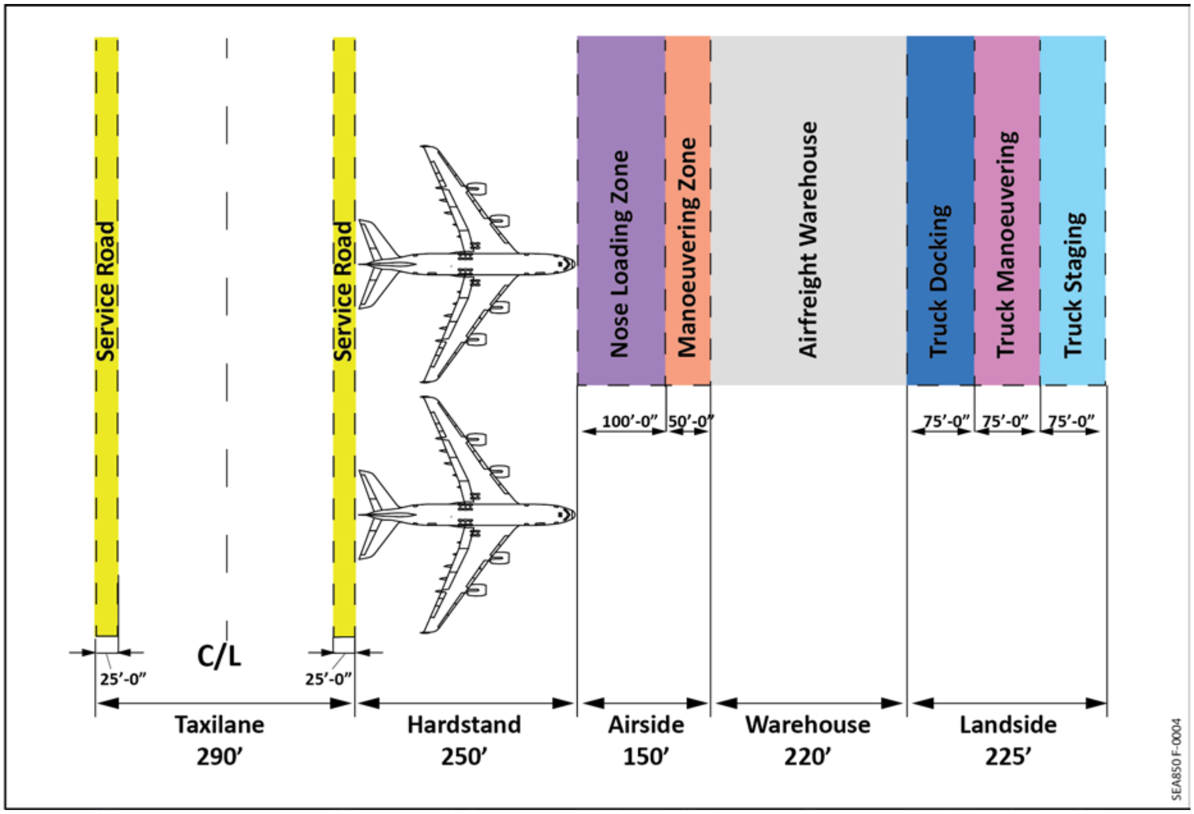
A feasible approach is to limit air freight warehouse facilities to conventional single level warehouses designed for moderate levels of automation, such as employing elevating transfer vehicle or lift and run container handling and storage techniques. This should permit productivity increases to a range of 0.7 to 1.0 tons per square foot per year.

5.3.1.4 Cargo Warehouse Site Components and Recommended Dimensions

Cargo warehouse site components and their concept dimensions were coordinated extensively with Port staff in a series of workshops.

Warehouse dimensions were developed for the key airside and landside site components based on experience of the planning team at other airports, the experience of Airport staff, and the practical limitations of land available at the Airport. The objective was to not to dictate the width of a future integrator warehouse, for example, but rather to ensure sufficient space for cargo campus development. The recommended dimensions for key cargo site components are shown graphically on Figure 5-2.

Figure 5-2
Recommended Dimensions for Key Cargo Warehouse Site Components
Seattle-Tacoma International Airport



Source: LeighFisher, 2015.

5.4 Cargo Activity Forecasts

The cargo facilities requirements were based on forecasts of total cargo volumes from *Technical Memorandum No. 4 Forecasts of Aviation Activity*. The planning activity levels and the forecast years corresponding with these planning levels are summarized in Table 52.

Table 5-2
Forecast Cargo Activity (metric tons)
Seattle-Tacoma International Airport

	Estimated 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Cargo volume					
Air freight	163,233	188,370	211,770	234,090	253,400
Integrator freight	105,505	110,590	116,990	123,750	130,900
Air mail	50,752	52,520	54,160	55,820	57,470
Total	319,490	351,480	382,920	413,660	441,770

Source: *Technical Memorandum No. 4 Forecasts of Aviation Activity*, LeighFisher, March 2015.

If the level of cargo activity proposed in the Century Agenda were to be achieved by 2037, the estimated cargo volumes that would be accommodated in the intervening years are shown in Table 53.

Table 5-3
Potential Cargo Activity Based on Century Agenda Goal for 2037 (tons)
Seattle-Tacoma International Airport

	Estimated 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034	2037
Cargo volume						
Air freight	164,444	201,895	247,784	304,325	373,631	422,578
Integrator freight	104,535	128,342	157,571	193,456	237,513	268,628
Air mail	50,863	52,520	54,160	55,820	57,470	58,794
Total	319,842	382,757	459,515	553,601	668,614	750,000

Sources:
Cargo volumes estimated by LeighFisher based on Port of Seattle Commission Century Agenda.
Activity for PALs 1 - 4 estimated by Logplan assuming (a) historical relationships among air freight, integrator freight, and mail, and (b) uniform compound annual growth between 2014 and 2037.

5.5 Cargo Warehouse and Freighter Hardstand Requirements

5.5.1 Cargo Warehouse Requirements

Cargo warehouse requirements were estimated (1) based on forecast cargo activity, shown in Table 52, (2) potential cargo activity based on the Century Agenda goal, shown in Table 53, and (3) assuming two operating concepts, as described in Section 5.3.1.3. Cargo warehouse requirements were estimated by dividing the annual forecast cargo volumes for air freight, integrator freight, and mail by assumed warehouse utilization rates. Utilization rates are shown in Table 54. Cargo warehouse requirements are presented in Table 55 and Table 56 for forecast activity and Century Agenda activity, respectively.

Table 5-4
Long-Term Warehouse Utilization Rates (tons/sq. ft. /yr.)
Seattle-Tacoma International Airport

	Air freight			
	Operating Model #1	Operating Model #2	Integrator Freight	Air Mail
Utilization	0.7	1.0	1.5	1.0

Source: Logplan, November 2014.

Table 5-5

Cargo Warehouse Requirements for Forecast Cargo Activity (sq. ft.)

Seattle-Tacoma International Airport

		Forecast			
Cargo type	Utilization (tons/sq. ft./yr.)	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Operating Concept #1					
Air freight	0.7	270,000	303,000	335,000	362,000
Integrator freight	1.5	74,000	78,000	83,000	87,000
Air mail	1.0	53,000	54,000	56,000	57,000
Total	n/a	397,000	435,000	474,000	506,000
Operating Concept #2					
Air freight	1.0	188,000	212,000	234,000	253,000
Integrator freight	1.5	74,000	78,000	83,000	87,000
Air mail	1.0	53,000	54,000	56,000	57,000
Total	n/a	315,000	344,000	373,000	397,000

Source: Logplan, November 2014.

Table 5-6

Cargo Warehouse Requirements for Century Agenda Cargo Activity (sq. ft.)

Seattle-Tacoma International Airport

		Forecast			
Cargo type	Utilization (tons/sq. ft./yr.)	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Operating Concept #1					
Air freight	0.7	288,000	354,000	435,000	534,000
Integrator freight	1.5	86,000	105,000	129,000	158,000
Air mail	1.0	53,000	54,000	56,000	57,000
Total	n/a	427,000	513,000	620,000	749,000
Operating Concept #2					
Air freight	1.0	202,000	248,000	304,000	374,000
Integrator freight	1.5	86,000	105,000	129,000	158,000
Air mail	1.0	53,000	54,000	56,000	57,000
Total	n/a	341,000	407,000	489,000	589,000

Source: Logplan, November 2014.

5.5.2 Freighter Hardstand Requirements

Freighter airline hardstand requirements, summarized in 5-7, were estimated based on an evaluation of scheduled and actual international freighter operations during the peak month, July 2014.

Table 5-7
Freighter Hardstand Requirements
Seattle-Tacoma International Airport

			Forecast			
	Typical Aircraft	Estimated 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
International freighters	B747-8F	4	5	5	6	6
Diverted flights and maintenance	B747-8F	2	2	3	3	3
Integrator freighters	B777-F	6	6	7	8	8
Domestic freighters	B737-F	2	2	2	2	2
Total		14	15	17	19	19

Source: LeighFisher, November 2014.

The strategy for planning freighter aircraft hardstands was to plan to accommodate B747-8F aircraft on new hardstands. The recommended dimensions for hardstands and the airside operating area are shown in Figure 5-3. If the present FedEx facility remains or is redeveloped at its present location, it is proposed that the existing freighter stands for this site will remain unchanged.

5.5.3 Landside Cargo Facilities Requirements

This section summarizes landside facilities requirements for air freight truck docks and maneuvering areas, truck staging areas, employee parking, customer parking, and access roads. These requirements are specifically applicable to air freight warehouses. Landside requirements associated with integrator and airmail warehouses or other warehouse support facilities should be developed as part of follow-on planning and design efforts.

Air freight truck dock requirements were estimated based on a planning factor of 0.3 truck docks per 1,000 square feet of air freight warehouse building, as recommended by the Airports Council International North America in its *Air Cargo Guide*. This planning factor is suitable for master planning only. These requirements are summarized in Table 5-8.

A distance of 150 feet from the face of the cargo warehouse to the access roadway would provide sufficient space for truck maneuvering. A one way traffic flow in the truck maneuvering area is preferred for maneuvering efficiency and safety.

Truck access to the truck docking and maneuvering area can be either controlled or un-controlled. With controlled access, a landside gate would be required to restrict vehicle access so that vehicles are only able to enter the truck docking or staging areas when sufficient docking or staging space is available. At present, uncontrolled access is the norm at the Airport; this approach should continue until conditions necessitate the implementation of controlled access.

Table 5-8
Air Freight Warehouse Dock Requirements
Seattle-Tacoma International Airport

		Forecast			
	Estimated 2014	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Forecast cargo activity					
Operating concept #1	70	81	91	100	109
Operating concept #2	49	57	64	70	76
Century Agenda cargo activity					
Operating concept #1	63	78	96	118	146
Operating concept #2	44	56	67	83	102

Source: Logplan, November 2014.

Truck staging areas contribute to efficient cargo operations, particularly when docks are occupied. These areas should be as close as possible to the truck docks. As cargo tonnage at the warehouses increases it may become necessary to provide remote staging areas and require trucks without a confirmed drop off or pick up reservation to report initially to the remote staging area, prior to being released to the assigned truck dock.

Typically, a minimum of two to eight employee parking spaces should be provided for every 1,000 square feet of warehouse and two to eight spaces for 1,000 square feet of office. Where development area is limited, alternative locations for employee parking should be considered. Employee and customer parking areas should be separate from truck maneuvering areas to improve efficiency and safety.

On-airport cargo warehouses are not typically high customer activity areas. An industry standard planning parameter for single tenant warehouses is a requirement of one customer parking space per 10,000 square feet of cargo building. If the warehouse is allocated to multiple tenants, a higher ratio is appropriate.

Airline Support

This chapter presents assessments of existing airline support facilities and summarizes the requirements that must be satisfied to accommodate the aviation activity forecast through the 20-year planning period.

6.1 Introduction

Airline support facilities include aircraft maintenance hangars, flight kitchens, ground handling service facilities, fuel storage and distribution facilities, and office space. This section identifies the airline support facilities considered during the SAMP, describes the existing facilities and operations, describes key planning assumptions, and summarizes airline support facility requirements for PAL 1 through PAL 4 (2019, 2024, 2029, and 2034, respectively).

6.2 Airline Support Facilities, Operations, and Requirements

6.2.1 Aircraft Maintenance Hangars

Alaska Airlines has two aircraft maintenance hangars located to the south of the South Satellite. Delta Air Lines has a single aircraft maintenance hangar located adjacent and to the east of the Alaska hangars. Neither Alaska Airlines nor Delta Air Lines has stated the requirement for additional aircraft maintenance hangars during the planning period. It is assumed therefore, that the current facilities are adequate for the planning period and, should they need to be relocated, they would be replaced in kind at a different on-Airport location.

6.2.2 Flight Kitchens

There are currently three providers of aircraft food and beverage services to the airlines (i.e., flight kitchens) operating at the Airport—Gate Gourmet, Flying Foods and SkyChef.

The airlines and their service providers are responsible for determining the requirements for the flight kitchens. Locating the flight kitchens on Airport property is a convenience but not a necessity. The Port's intention is to continue leasing convenient on-Airport property to the service providers as long as the property is not needed for a higher-priority use.

6.2.3 Ground Handling Services Facilities

Airline ground handling services include aircraft loading and unloading, fueling, de-icing; baggage sorting, ground power unit service, aircraft push-back and towing, aircraft servicing and cleaning, aircraft security, and ground service equipment repair and maintenance. Ground handling services are currently provided at the Airport by airline personnel and third party providers Aircraft Service International Group and Swissport operating from leased facilities.

The future requirements for ground handling services facilities at the Airport will increase as the volume of passenger and aircraft activity increases. Because the Airport is land poor, most facilities accommodating ground handling services will be demolished to allow the development of additional gates. Therefore, both the ground handling services facilities requirements and locations will be changing. The specific requirements for such new facilities will be determined during the advanced planning after the SAMP is completed.

6.2.4 Fuel Storage and Distribution Facilities

Jet fuel is delivered to the Airport from multiple refineries in Northern Washington via the Olympic Pipeline. The deliveries of jet fuel share capacity in the pipeline with other petroleum products being delivered as far south as Eugene Oregon. There is concern about the operational impact at the Airport, of supply disruptions and the potential requirement for a backup delivery source other than over-the-road tankers (e.g., a second pipeline). The need for, and ability to implement, such a backup delivery source would involve off-Airport facilities and should be explored in advanced planning.

The Airport's airline fuel storage facilities (i.e., the fuel "farm") consist of eight above-ground storage tanks with a total gross capacity of 17,331,000 gallons of fuel. The Port leases the fuel farm land to the fuel system owner, SeaTac Fuel Facilities Inc. Fuel for general aviation is stored separately by the FBO in underground storage tanks located on the FBO leasehold.

Requirements for the future fuel tank storage capacity were based on an analysis of historical fuel flowage and aircraft operations data for 2014 and the following planning guidelines and assumptions:

- Peak fuel demand calculations are based upon the average day peak month (ADPM) operations.
- In July 2014 (the peak month for fuel flowage), an average of 3,342 gallons of jet fuel per departure was dispensed and the fuel farm had 8.8 days of fuel reserves.
- Future jet fuel requirements were projected by determining the product of three factors: forecast ADPM for passenger and cargo airline departures, average jet fuel dispensed per aircraft departure in the peak month, and the number of day's reserves desired.

Projected jet fuel storage requirements are presented in Table 6-1.

The existing underground fuel distribution system delivers fuel to 167 hydrant pits located at fixed aircraft parking positions. The system is well maintained and can be expanded to meet future fueling needs as the Airport's gate facilities are expanded.

Table 6-1
Projected ADPM Airline Jet Fuel Demand and Gross Storage Required to Provide 3-, 5-, 7-, and 10-Day Reserves
Seattle-Tacoma International Airport

	2014 Baseline	PAL 1 2019	PAL 2 2024	PAL 3 2029	PAL 4 2034
Annual aircraft operations *(a)*	340,478	398,910	448,860	497,180	540,400
Peak month aircraft operations *(b)*	32,615	38,264	43,098	47,774	51,956
ADPM aircraft operations *(c)*	1,302	1,417	1,571	1,743	1,901
ADPM average jet fuel dispensed per departure (gallons) *(d)*	3,348	3,348	3,348	3,348	3,348
ADPM jet fuel demand (gallons) *(e)*	2,179,500	2,372,100	2,629,900	2,917,800	3,182,300
Gross jet fuel storage requirements (gallons) *(f)*					
3-day reserve supply	7,265,000	7,907,000	8,766,300	9,726,000	10,607,700
5-day reserve supply	12,108,300	13,178,300	14,610,600	16,210,000	17,679,400
7-day reserve supply	16,951,700	18,449,700	20,454,800	22,694,000	24,751,200
10-day reserve supply	24,216,700	26,356,700	29,221,100	32,420,000	35,358,900

(a) From LeighFisher, *Technical Memorandum 2 - Aviation Demand Forecasts, March 2015*.
(b) Calculated based upon flight schedules for both passenger and cargo airlines.
(c) Calculated based upon flight schedules for both passenger and cargo airlines.
(d) Based on jet fuel dispensed per departure in July 2014.
(e) Calculated by multiplying ADPM departures (total operations divided by two) by the ADPM average jet fuel dispensed per departure.
(f) Includes adjustment factor to account for "bottoms" in the tank (90% of gross tank capacity contains usable fuel).

Source: Corich Group LLC based on Port of Seattle data, March 2015.

6.2.5 Office Space

Airline office space is located both in non-secure areas (e.g., the Main Terminal) and secure areas (e.g., apron level areas beneath the concourses and satellites). As part of the SAMP, the airlines have not stated requirements for additional office space. Nevertheless, it is anticipated that such requirements at the Airport will change as the volume of passenger and aircraft activity increases.

It is assumed that (a) the amount of space available for airline offices will increase in the future as additional passenger terminal and gate facilities are provided, (b) the specific needs for office space will be determined following completion of the SAMP, and (c) the Port will continue to reallocate existing office space to meet changing future needs.

Airport Support

This chapter presents assessments of existing airport support facilities and summarizes the requirements that must be satisfied to accommodate the aviation activity forecast through the 20-year planning period.

7.1 Introduction

Airport support facilities considered in the SAMP include those related to aviation maintenance, aircraft rescue and firefighting, aircraft ground run-up, concessions distribution, recycling and composting, and utilities. This section summarizes these Airport support facilities and their requirements for PAL 1 through PAL 4 (2019, 2024, 2029, and 2034, respectively).

7.2 Aviation Maintenance Facilities

The Aviation Maintenance Department maintains and supervises all Port-owned assets that are necessary for the Airport to function. The work of the Maintenance Department is conducted from facilities shown on Figure 7-1.

We anticipate that the recommended development plan may result in the need to relocate aviation maintenance facilities within SASA (i.e., the aviation maintenance distribution center, Port employee parking, and the rental car shuttle bus maintenance facility), the Cargo 4 complex, and possibly some or all of the facilities near the snow removal and large equipment storage area. The functions at each of these locations were analyzed to estimate the requirements for siting replacement facilities, should they be needed.

- **SASA**. The specific program for the replacement maintenance distribution center, Port employee parking lot, and rental car shuttle bus maintenance facility should be determined during advanced planning. For the purposes of SAMP, we assumed that if facilities are relocated, sites sufficient to accommodate facilities similar to those being relocated will be required.

- **Cargo 4.** The Cargo 4 complex accommodates functions that include vehicle maintenance, vehicle storage, the carpentry shop, and the paint shop. The largest most demanding function is vehicle maintenance. The current footprint for the facilities at Cargo 4 is approximately 4.5 acres. If Cargo 4 is relocated, a 6 acre site with access to public streets as well as direct access to the airfield is recommended. The specific program for the replacement facilities, if needed, should be determined during advanced planning.

- **Snow removal equipment and large vehicle storage.** The snow equipment and large vehicle storage shed provide open storage for snow plows, airfield runway de-icing chemicals, large trucks, and mowers. The current footprint for the facilities is approximately 5.3 acres. If these facilities are relocated, a site footprint of 7 acres is recommended. The specific program for the replacement facilities, if needed, should be determined during advanced planning.

Figure 7-1
Location of Existing Maintenance Facilities and Shops
Seattle-Tacoma International Airport

Source: Port of Seattle, 2016.

7.3 Aircraft Rescue and Firefighting Facilities

The Airport's existing fire station is on a site of approximately 3.8 acres located at 2400 South 170th Street. We anticipate that the expansion of the Airport's passenger terminal facilities will require that the existing fire station be demolished and replaced with one or more new facilities. The requirements that will dictate the future ARFF facility or facilities and allow the Department to continue providing its existing (excellent) level of service are summarized below.

- **ARFF vehicle response time**. The FAA mandates that (a) the Department's first aircraft crash truck be able to reach the center of the runway that is furthest from the station within three minutes of the alarm sounding, and (b) two additional vehicles be able to reach the same point within four minutes.

- **ARFF fuel spill response**. An ARFF truck must be located near the terminal gates in order to quickly respond to fuel spills to prevent or extinguish any fires and to reduce the chances of environmental contamination.

- **Medical response**. A new fire station must be close enough to the passenger terminal to maintain the Department's ability to respond rapidly to medical emergencies.

- **Structural fire response**. The station or stations must be located to permit rapid responses to structural fires at any of the Airport's facilities.

The requirements for replacement fire station sites were developed based on Advisory Circular AC150-5210-15A Aircraft Rescue and Fire Fighting Station Building Design and discussions with the Fire Chief regarding the operating characteristics of the SEA fire department.

If the existing fire station is replaced by a single station, then a site with an area of approximately four acres is required. If the existing fire station is replaced by two stations (e.g., one east-side station and one west-side station), then each site would require approximately two acres.

7.4 Aircraft Ground Run-up Enclosure

A ground run-up enclosure (GRE) is a three-sided structure used to minimize aircraft ground run-up noise generated when maintenance personnel test aircraft engines. There is no GRE at the Airport.

A site of approximately two acres with taxiway access is required for an aircraft ground run up enclosure. We recommend that such a site be identified and included in SAMP.

7.5 Centralized Receiving Warehouse

Goods utilized by the Airport's concessionaires currently arrive via multiple daily semi-truck deliveries. The trucks enter the Airport through security gates and travel across the apron to reach multiple receiving docks where the goods are unloaded.

A centralized receiving warehouse is required to (1) eliminate unneeded vehicle traffic from the apron, (2) provide a single location for all Airport deliveries, and (3) enhance security by providing a centralized location at which all Airport deliveries are inspected, prior to delivery to the concessionaires.

7.6 Trash, Recycling, and Compost

Trash collecting, recycling, and composting functions are currently accomplished using dumpsters and compactors at several locations in the terminals and on the airfield. The current facilities are at or nearing capacity and have no room to accommodate growth. The operational "work arounds" currently employed to manage the solid waste streams are increasingly difficult, costly, and are generating significant additional waste hauler truck traffic within the Airport Operations Area.

The requirement is for a centralized waste processing facility at which compactors and dumpsters may be dropped off and picked up and waste may be sorted and pre-processed. Such a facility is expected to facilitate the Port's ability to manage the movement of waste, minimize long-term costs, free airfield space for higher and better uses, contribute to more sustainable operations, and keep third-party waste hauling trucks off the airfield.

7.7 Utilities

The Airport's existing utility infrastructure systems (i.e., electrical, mechanical, sanitary sewer, storm water drainage, and industrial waste) are described in Section 7.2.4 of *Technical Memorandum No. 2 Existing Conditions Inventory*. This existing utility infrastructure and the supply of supporting regional infrastructure (e.g., power, water, and sewerage) are generally adequate to meet current and future needs.

The facilities changes needed to permit the Airport to accommodate the forecast PAL 4 (2034) demand of approximately 66 million annual passengers will be extensive as will be the number of projects required to support this growth. The utilities requirements associated with these future projects will be determined by the specifics of each project (e.g., we know that a second passenger terminal, if desired, will require a stand-alone utility plant).

Accordingly, the recommended approach to utilities requirements is to estimate utilities issues and requirements to the extent appropriate for the purposes of cost estimating during the alternatives phase of SAMP and conduct more detailed requirements analyses during detailed planning and design that will follow the SAMP.

There are known requirements for utility system modifications that are currently being planned outside the SAMP (e.g., modifications required to the industrial waste system).

General Aviation

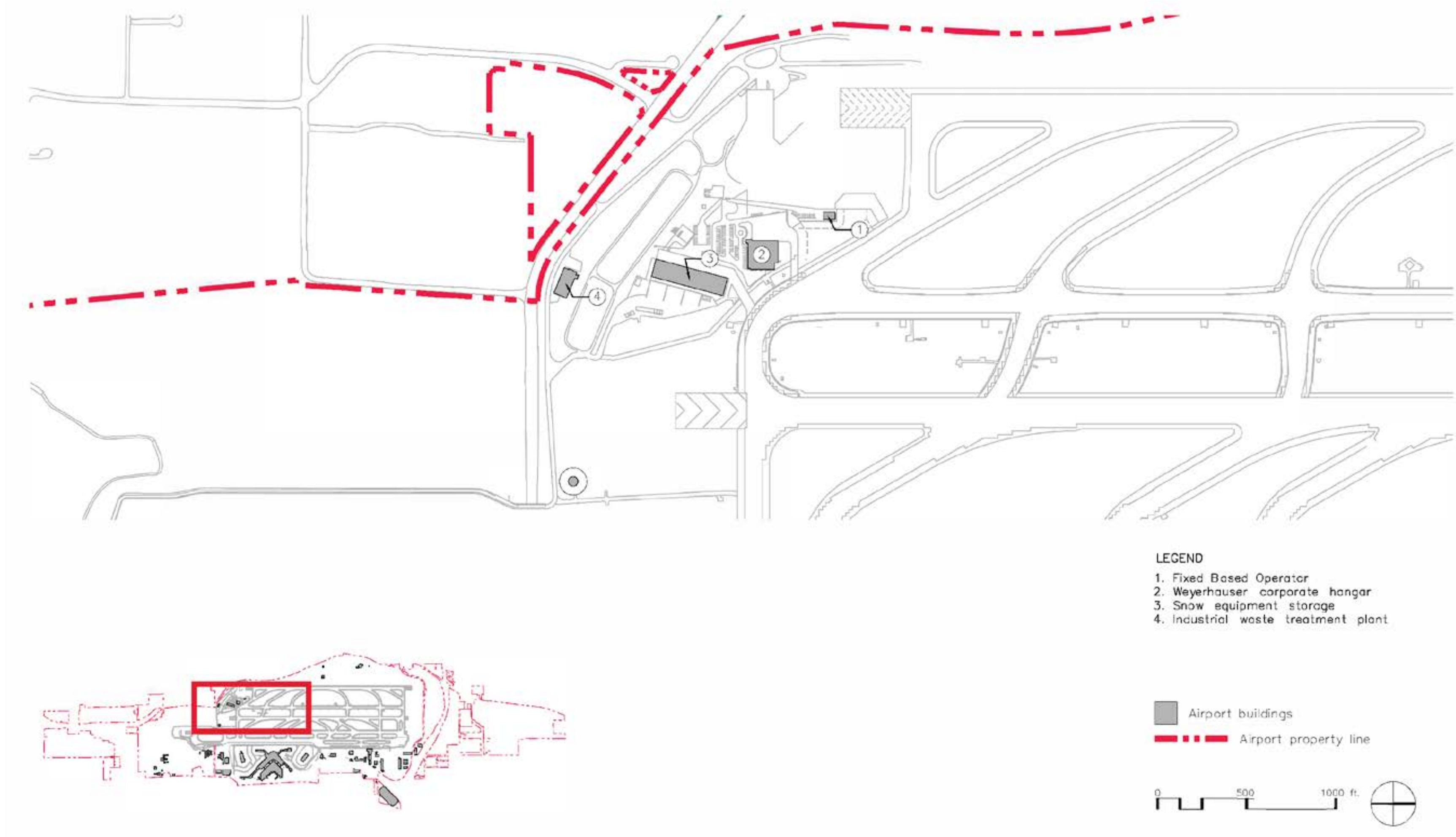
This chapter summarizes the requirements for general aviation facilities through the 20-year planning period.

General aviation (GA) facilities at the airport consist of a corporate aircraft hangar located on a site leased by the Weyerhaeuser Corporation, a fixed base operator (FBO) building, and an adjacent 48,000-square foot (approximate) itinerant aircraft apron owned by the Port. These facilities are located in the southwest quadrant of the Airport as shown on Figure 8-1.

In 2014, the Airport accommodated an average of approximately 11 daily GA operations. In 2016, the number of average daily GA operations decreased to approximately 8 operations. By PAL 4, the average number of daily GA operations is forecast to increase slightly, to approximately 12 daily operations.

Consistent with the Port's philosophy of compliance with FAA grant assurances, it is recommended that the site utilized to accommodate itinerant GA aircraft (i.e., the site accommodating both the FBO building and itinerant GA aircraft apron) be retained; it is adequate to accommodate demand through PAL 4 (2034); no increase in size is recommended. There is no requirement to continue leasing land to the Weyerhaeuser Corporation for its corporate hangar.

Figure 8-1
General Aviation Facilities
Seattle-Tacoma International Airport



Source: Port of Seattle, 2014.

Appendix A—Approach to Developing Design Day Flight Schedules

Appendix A—Approach to Developing Design Day Flight Schedules

Development of Design Day Future Schedules

This section summarizes the development of design day future schedules (DDFS) for the average day peak month (ADPM) at the Airport for 2014, 2016, 2019, 2024, 2029, and 2034. The forecasts of ADPM aircraft operations and passengers are derived from the annual forecasts presented in the technical memorandum "Forecasts of Aviation Activity".

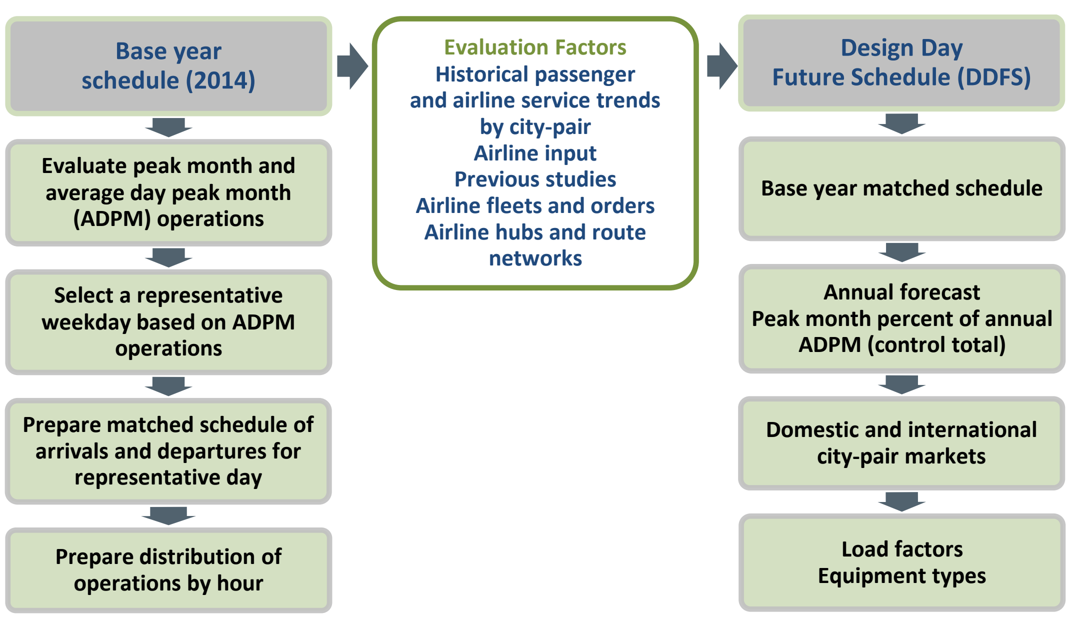
Design Day Future Schedules

A DDFS is defined as "a constructed schedule showing individual aircraft arrivals and departures by time of day and aircraft type that can also show airline, O&D, and the number of passengers associated with each flight, depending on the level of detail required."* For the SEA SAMP, the DDFSs were used to evaluate the requirements for the airfield/airspace and the passenger terminal complex.

Approach

DDFSs represent the level of activity that typically occurs on an average day in the peak month. The historical relationship between annual, peak month, and ADPM activity is evaluated to provide a basis for the selection of a representative week day from published airline schedules, as shown in Figure A-1.

Figure A-1
Design Day Future Schedule Approach



*ACRP Report 163, Guidebook for Preparing and Using Airport Design Day Flight Schedules, 2016.

Average Day Peak Month

In 2014, the peak month (July) accounted for 9.9% of passenger airline operations and 10.2% of passengers, as shown in Table A-1. It was assumed that the peak month would continue to account for the same percentages of annual operations and passengers in future years. ADPM activity, calculated by dividing the peak month by 31 days, represents the “control totals” for the selection of a representative day from published airline schedules in 2014 and for the development of schedules for future years.

Table A-1
Historical and Forecast Peak Period Demand
Seattle-Tacoma International Airport

	Historical		Baseline forecast			
	2014	2016	2019	2024	2029	2034
Total passengers (enplaned and deplaned)						
Annual	37,498,267	45,736,700	44,815,200	51,827,400	58,921,600	65,647,200
Peak month	3,824,823	4,665,143	4,571,150	5,286,395	6,010,003	6,696,014
Peak month percent of annual	10.2%	10.2%	10.2%	10.2%	10.2%	10.2%
Average day peak month (ADPM)	123,381	150,488	147,456	170,529	193,871	216,000
Peak hour passengers	9,928	10,657	11,021	12,106	12,938	14,132
Passenger airline scheduled aircraft operations (arrivals and departures)						
Annual operations	324,372	400,000	381,100	430,300	477,820	520,400
Peak month	31,996	39,456	37,592	42,445	47,132	51,332
Peak month percent of annual	9.9%	9.9%	9.9%	9.9%	9.9%	9.9%
Average day peak month (ADPM)	1,032	1,273	1,213	1,369	1,520	1,656
Peak hour operations	88	95	95	102	113	125

Note: The forecasts presented in this table were prepared using the information and assumptions given in the accompanying text. Inevitably, some of the assumptions used to develop the forecasts will not be realized and unanticipated events and circumstances may occur. Therefore, there are likely to be differences between the forecast and actual results, and those differences may be material.
The base year for the forecasts is 2014.

Sources: Historical--Seattle-Tacoma International Airport records and OAG Worldwide Aviation Ltd, online database, accessed August 2014 and September 2016.
Forecast--LeighFisher, September 2014.

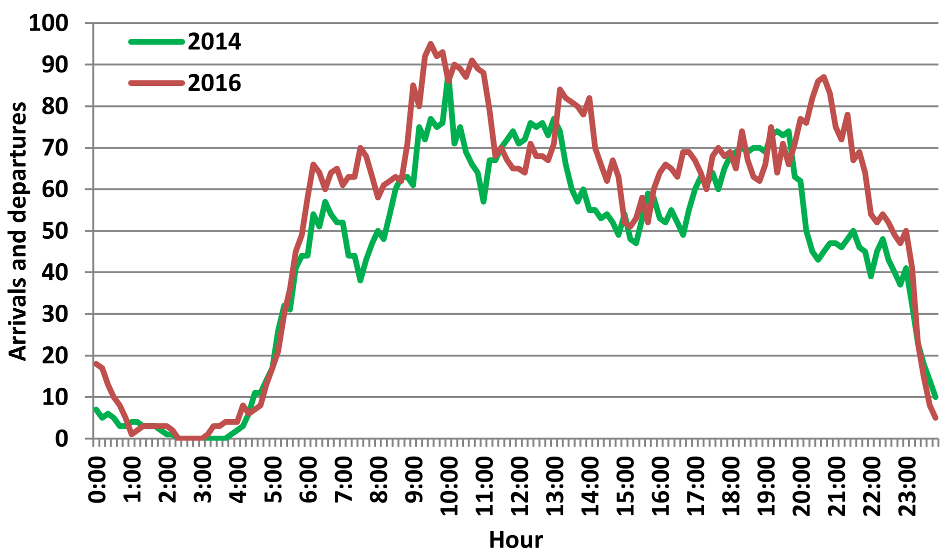
Base Year Matched Schedule

A matched schedule of arrivals and departures for 2014 was prepared using LeighFisher's proprietary software. Arriving and departing flights with the same aircraft type, seat configuration, and airline were matched and evaluated based on reasonable stand times. In addition, a review of airline schedules for 2016 was conducted to evaluate changes related to the development of Delta's hubbing operations at SEA and the competitive responses by other airlines. As shown in Figure A-2, a comparison of the hourly distribution of flights in the 2014 and 2016 schedules indicates that:

- The 2016 schedule is more peaked than the 2014 schedule
- The morning peak in 2016 occurs earlier in the day
- The valley between 6:00 am and 8:00 am in 2016 has been filled
- The evening peak in 2016 occurs later in the day
- An additional peak or bank occurs at approximately 5:00 pm
- Considerable down time (valleys) is included in the 2016 schedule

In consideration of the changes noted above, the DDFSs were revised to reflect the hourly distribution in the 2016 matched schedule. Figure A-3 shows the hourly distribution of operations in 2016 and the future years.

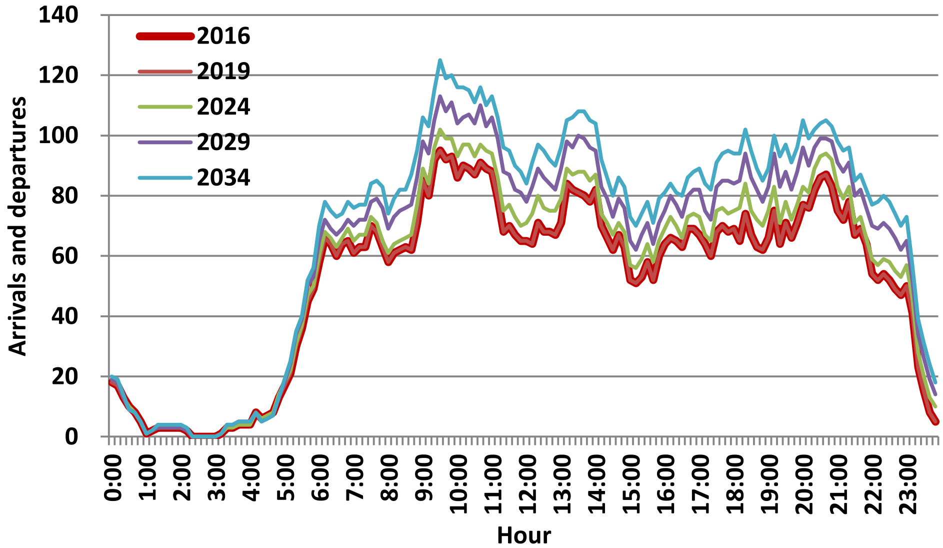
Figure A-2
Comparison of Rolling Hour Arrivals and Departures in 2014 and 2016
Seattle-Tacoma International Airport



Note: Rolling hour is a 10-minute look ahead.

Source: OAG Worldwide Aviation Ltd, Schedules Analyser, accessed August 2014 and September 2016.

Figure A-3
Historical and Forecast Rolling Hour Arrivals and Departures
Seattle-Tacoma International Airport



Note: Rolling hour is a 10-minute look ahead.

Sources: 2016—OAG Worldwide Aviation Ltd, Schedules Analyser, accessed September 2016.
Forecast—LeighFisher, September 2014.

Evaluation Factors

A number of factors were used to evaluate and develop DDFSs for SEA, including:

- A bottom-up analysis of passenger airline service and passenger traffic by city-pair market for domestic and international sectors
- Analyses conducted in previous studies for NorthStar and the International Arrivals Facility
- Input from airlines, the Port of Seattle air service department, and other stakeholders
- Airline fleets and aircraft orders, including the average age of existing aircraft, estimated useful lives, and the timing of aircraft deliveries
- Airline hubs, route networks, and banking patterns

Appendix B—Working Paper – Gate Requirements Summary

Leigh|Fisher

Gate Requirements Summary

Port of Seattle

Sustainable Airport Master Plan

Prepared for:

Port of Seattle

June 2, 2015

Sustainable Airport Master Plan
Seattle-Tacoma International Airport

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FIGURES

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APPROACH TO ESTIMATING GATE REQUIREMENTS

- In this document, the term "gate" refers to an aircraft parking position
  - A contact gate is an aircraft parking position equipped with a passenger boarding bridge connected to the passenger terminal
  - An "off-gate" parking position is typically located away from, but relatively near to contact gates and is also known as a hardstand or remain overnight aircraft parking position

- Contact gate requirements and off-gate aircraft parking requirements were estimated for 2019, 2024, 2029, and 2034 (Planning Activity Levels (PAL) 1, 2, 3, and 4, respectively)

- Estimating tool was LeighFisher's gate model; inputs to gate model included:
  - Planning day flight schedules developed for each PAL (schedules included aircraft type, arrival time, and departure time for each scheduled flight)
  - Buffer time required between scheduled gate activity (refer to attached gate model assumptions and Tables 1 and 2)
  - Rules related to gate sharing among airlines (sharing is always permitted within the groups of activity described below, sharing between groups is permitted on an exception basis)
  - Rules governing aircraft towing to and from remain overnight and off-gate parking positions (all towing operations are estimated to require 15 minutes)

- Contact gate requirements were estimated for four groups of activity that reflect differing requirements to be included in the long-range development plan
  - **International** gates were grouped because of the requirement that each be connected to the FIS facilities by a sterile corridor and the need to prioritize their use for international arrivals
  - **Delta domestic** gates were grouped because of Delta's increasing volume of activity on the south half of the Airport and the relationship of its domestic network to its growing international hub
  - **Alaska Air Group** gates were grouped because of the Group's market share at the Airport (greater than 50%) and dominant position
  - **Other domestic** gates were grouped as a logical consequence of the three primary groups

- Off-gate aircraft parking requirements were estimated for two groups of activity that reflect a potential split between requirements for the south and north Airport)
  - International and Delta domestic
  - Other domestic

- Gate requirements are summarized graphically in "ramp charts" (i.e., Gantt charts) produced by the gate model

- Approach ensures the estimated requirements represent the minimum number of new gates (i.e., aircraft parking positions) needed to accommodate the scheduled activity
  - Gate requirements were unconstrained by existing infrastructure (e.g., gate requirements were estimated by gating aircraft based on model inputs and the capabilities of parking positions created by the model; existing restrictions related to geometry, passenger boarding bridges, or ramp striping were not considered)
  - Maximum gate sharing
  - Benchmark comparison against existing gate inventory
- The number of gates required to accommodate a given schedule is not a single number, but a range of numbers. The number of gates required can vary depending on factors such as fleet mix, the allowance provided for off-schedule operations, gate sharing

GATE MODEL ASSUMPTIONS

Minimum Arrival and Departure Times

Assumptions for the minimum duration of time required on gate to process arrival and departure operations are shown in Table 1. These are the amounts of time that an aircraft occupies a gate to complete an arrival or a departure operation, respectively.

Earliness and Lateness Buffers

Earliness and lateness buffers allow for schedule variability by reserving blocks of gate time for flights that may be early or late relative to schedule. In the Gate Model all flights are assumed to arrive and depart on schedule. These buffers provide a time "cushion" between successive gate operations. The earliness and lateness buffers used for international flights were derived by analyzing historic operations data for SEA. The earliness and lateness buffers shown in Table 2 represent the 85th percentile values for arrival time variance; i.e., 85 percent of the time the flight arrives within the span of time given by: (Scheduled Arrival Time -Earliness Buffer) + (Scheduled Arrival Time + Lateness Buffer).

Minimum Turn Times

The assumed minimum time on gate to turn an aircraft, i.e., the minimum time to unload arriving passengers, exchange baggage, refuel, cater, and load departing passengers in quick succession, is shown in Table 2. In the Gate Model, aircraft with scheduled ground times less than or equal to the minimum turn time will have a full lateness buffer applied after the scheduled departure time. Aircraft with scheduled ground times greater than the minimum turn time will have either a shortened lateness buffer or no lateness buffer applied depending on how much "slack" is provided in their scheduled ground time.

Maneuver Buffer

The assumed amount of time that a gate is unavailable while aircraft and equipment are maneuvered into and out of position is shown in Table 2. In the Gate Model, a maneuver buffer is applied after each departure from a gate.

Aircraft Towing

The Gate Model permits aircraft with scheduled ground times significantly greater than the sum of the minimum arrival and minimum departure times to be towed and parked remotely in order to make gates available for active operations. "Significantly greater" is defined as 45 minutes.

All aircraft towing operations to move an idle aircraft to a remote position or another gate from its starting position are allotted 15 minutes. Similarly, an aircraft towing operation from a remote position to an active gate for departure is also allotted 15 minutes.

Table 1
Minimum Arrival and Departure Times (Minutes)

Aircraft Seats	Arrival	Departure
400+	NA	NA
200-399	45 (domestic) 60 (international)	45 (domestic) 60 (international)
100-199	30 (domestic) 60 (international)	30 (domestic) 60 (international)
0-99	25	25

Table 2
Buffer and Turn Times (Minutes)

Region	Earliness Buffer	Lateness Buffer	Maneuver Buffer
Asia	43	42	10
Canada	21	10	10
Europe	37	30	10
Mexico	10	10	10
Domestic	10	10	5

TABLE 3

EXISTING GATE AND OFF-GATE PARKING INVENTORY

Summary of detailed inventory on tab 'Positions'

POSITION TYPE / Sector / Location	Mix A (b) RJ/TP	Mix A (b) Jet III	Mix A (b) Jet IV	Mix A (b) Jet V	Mix A (b) Jet VI	Total Mix A	Mix B (b) RJ/TP	Mix B (b) Jet III	Mix B (b) Jet IV	Mix B (b) Jet V	Mix B (b) Jet VI	Total Mix B
GATES (a)												
International	1	1	6	5	2	15	1	-	2	8	2	13
Domestic	26	31	18	2	-	77	20	32	12	6	-	70
TOTAL GATES	**27**	**32**	**24**	**7**	**2**	**92**	**21**	**32**	**14**	**14**	**2**	**83**

Notes

(a) Parking positions that can accommodate loading/unloading of passenger airline aircraft.

(b) The number positions that can be simultaneously occupied on a given ramp area may vary based on configuration and layout. Flexibly configured aprons can accommodate various discrete combinations of small and large aircraft. 'Mix A' presents the upper bound of the number of aircraft that can be accommodated assuming the smallest aircraft size mix and 'Mix B' presents the lower bound assuming the largest aircraft size mix.

TABLE 4

AIRCRAFT GATE AND PARKING REQUIREMENTS - 2019

Gate Model results assuming no infrastructure constraints

Based on the 2019 ramp chart

Comparable with Mix B of existing gate inventory

POSITION TYPE / Sector or Activity Description / Activity group	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
GATES (a)						
International	-	-	2	16	-	18
Domestic	19	47	10	1	-	77
TOTAL GATES	**19**	**47**	**12**	**17**	**-**	**95**
OFF-GATE PARKING						
Total Demand	6	31	5	4	-	46
Demand accommodated at gates (b)	5	11	2	-	-	18
NET OFF-GATE PARKING REQUIREMENT	**1**	**20**	**3**	**4**	**-**	**28**

GATE / OFF-GATE PARKING RATIO	3.4
TOTAL GATE + OFF-GATE POSITIONS	123

Notes

(a) Includes all activity by foreign flag carriers (except Air Canada) and international arrivals by Alaska Air Group and Delta.

(b) Off-gate parking demand that could be accommodated on available gates as determined by visual inspection of Gate Model ramp charts.

TABLE 5

AIRCRAFT GATE AND PARKING REQUIREMENTS - 2024

Gate Model results assuming no infrastructure constraints

Based on the 2024 ramp chart

Comparable with Mix B of existing gate inventory

POSITION TYPE / Sector or Activity Description / Activity group	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
GATES (a)						
International	-	1	2	19	-	22
Domestic	21	50	10	1	-	82
TOTAL GATES	**21**	**51**	**12**	**20**	**-**	**104**
OFF-GATE PARKING						
Total Demand	7	38	4	3	-	52
Demand accommodated at gates (b)	5	16	-	-	-	21
NET OFF-GATE PARKING REQUIREMENT	**2**	**22**	**4**	**3**	**-**	**31**

GATE / OFF-GATE PARKING RATIO	3.4
TOTAL GATE + OFF-GATE POSITIONS	135

Notes

(a) Includes all activity by foreign flag carriers (except Air Canada) and international arrivals by Alaska Air Group and Delta.

(b) Off-gate parking demand that could be accommodated on available gates as determined by visual inspection of Gate Model ramp charts.

TABLE 6

AIRCRAFT GATE AND PARKING REQUIREMENTS - 2029

Gate Model results assuming no infrastructure constraints

Based on the 2029 ramp chart

Comparable with Mix B of existing gate inventory

POSITION TYPE Sector or Activity Description Activity group	Aircraft size category					
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
GATES (a)						
International	-	-	2	22	-	24
Domestic	21	51	8	2	-	82
TOTAL GATES	**21**	**51**	**10**	**24**	**-**	**106**
OFF-GATE PARKING						
Total Demand	7	42	6	4	-	59
Demand accommodated at gates (b)	4	15	3	-	-	22
NET OFF-GATE PARKING REQUIREMENT	**3**	**27**	**3**	**4**	**-**	**37**

GATE / OFF-GATE PARKING RATIO	2.9
TOTAL GATE + OFF-GATE POSITIONS	143

Notes

(a) Includes all activity by foreign flag carriers (except Air Canada) and international arrivals by Alaska Air Group and Delta.

(b) Off-gate parking demand that could be accommodated on available gates as determined by visual inspection of Gate Model ramp charts.

TABLE 7

AIRCRAFT GATE AND PARKING REQUIREMENTS - 2034

Gate Model results assuming no infrastructure constraints

Based on the 2034 ramp chart

Comparable with Mix B of existing gate inventory

POSITION TYPE Sector or Activity Description Activity group	Aircraft size category					
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	Total
GATES (a)						
International	-	2	-	27	-	29
Domestic	12	63	6	3	-	84
TOTAL GATES	**12**	**65**	**6**	**30**	**-**	**113**
OFF-GATE PARKING						
Total Demand	7	47	5	7	-	66
Demand accommodated at gates (b)	3	17	2	-	-	22
NET OFF-GATE PARKING REQUIREMENT	**4**	**30**	**3**	**7**	**-**	**44**

GATE / OFF-GATE PARKING RATIO	2.6
TOTAL GATE + OFF-GATE POSITIONS	157

Notes

(a) Includes all activity by foreign flag carriers (except Air Canada) and international arrivals by Alaska Air Group and Delta.

(b) Off-gate parking demand that could be accommodated on available gates as determined by visual inspection of Gate Model ramp charts.

Table 8
INCREMENTAL GATE REQUIREMENTS - 2019, 2024, 2029, and 2034

	Existing Gate Inventory			2019 Requirements					
	Widebody Mix B[a]			Absolute[b]			Incremental (over existing)		
	Int	Dom	Total	Int	Dom	Total	Int	Dom	Total
RJ/TP	1[c]	20	20	-	19	19	-	-	-
Jet III	-	32	32	-	47	47	-	15	15
Jet IV	2	12	14	2	10	12	-	(2)	(2)
Jet V	8	6	14	16	1	17	8	(5)	3
Jet VI	2	0	2	-	-	-	(2)	-	(2)
Total	12	70	82[d]	18	77	95	6	8	14

	Existing Gate Inventory			2024 Requirements					
	Widebody Mix B[a]			Absolute[b]			Incremental (over existing)		
	Int	Dom	Total	Int	Dom	Total	Int	Dom	Total
RJ/TP	1[c]	20	20	-	21	21	-	1	1
Jet III	-	32	32	1	50	51	1	18	19
Jet IV	2	12	14	2	10	12	-	(2)	(2)
Jet V	8	6	14	19	1	20	11	(5)	6
Jet VI	2	0	2	-	-	-	(2)	-	(2)
Total	12	70	82	22	82	104	10	12	22

	Existing Gate Inventory			2029 Requirements					
	Widebody Mix B[a]			Absolute[b]			Incremental (over existing)		
	Int	Dom	Total	Int	Dom	Total	Int	Dom	Total
RJ/TP	1[c]	20	20		21	21	-	1	1
Jet III	-	32	32		51	51	-	19	19
Jet IV	2	12	14	2	8	10	-	(4)	(4)
Jet V	8	6	14	22	2	24	14	(4)	10
Jet VI	2	0	2	-	-	-	(2)	-	(2)
Total	12	70	82	24	82	106	12	12	24

	Existing Gate Inventory			2034 Requirements					
	Widebody Mix B[a]			Absolute[b]			Incremental (over existing)		
	Int	Dom	Total	Int	Dom	Total	Int	Dom	Total
RJ/TP	1[c]	20	20	-	12	12	-	(4)[e]	(4)[e]
Jet III	-	32	32	2	63	65	2	31	33
Jet IV	2	12	14	-	6	6	(2)	(6)	(8)
Jet V	8	6	14	27	3	30	19	(3)	16
Jet VI	2	0	2	-	-	-	(2)	-	(2)
Total	12	70	82[e]	29	84	113	17	18	35

a. The number of aircraft that can be acccommodated on the Airport's existing gates depends on the number of widebody aircraft included in the mix.
- Mix A is the mix that yields the maximum number of aircraft.
- Mix B is the mix that yields the maximum number of widebody aircraft.

The gate count shown excludes one RJ postion at the South Satellite.

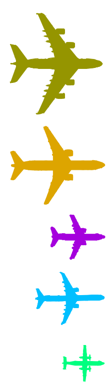
b. Source: Redacted gate charts

c. One existing international RJ position was not counted in the current total since it cannot be used to accommodate any aircraft during future planning periods.

d. One RJ position is not needed in the 2019 requirements, so the total usable number of positions (as seen in the 2019 Gantt Chart) is 81 instead of 82.

e. Eight RJ positions are unneeded in the 2034 forecast and can be replaced with 4 Jet III positions. The 8 unneeded positions are the southernmost Concourse C gates (Q1 - Q8). Therefore, the total usable number of positions (as seen in the 2034 Gantt Chart) is 78 instead of 82.

LEGEND



Location	Aircraft size category					Total
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	
International						
South Satellite	1	1	6	5	2	15
Domestic						
Concourse A	2	4	7	2		15
Concourse B	1	5	7	-	-	13
Concourse C	14	6	-	-	-	20
Concourse D	-	6	4	-	-	10
North Satellite	9	10	-	-	-	19
Subtotal	26	31	18	2	-	77
TOTAL GATES	**27**	**32**	**24**	**7**	**2**	**92**

Note: The number of aircraft that can be accommodated on the available ramp varies based on factors including facilities, operating practice, and aircraft mix. "Mix A" represents an upper bound of the number of aircraft assuming fewer widebody aircraft.

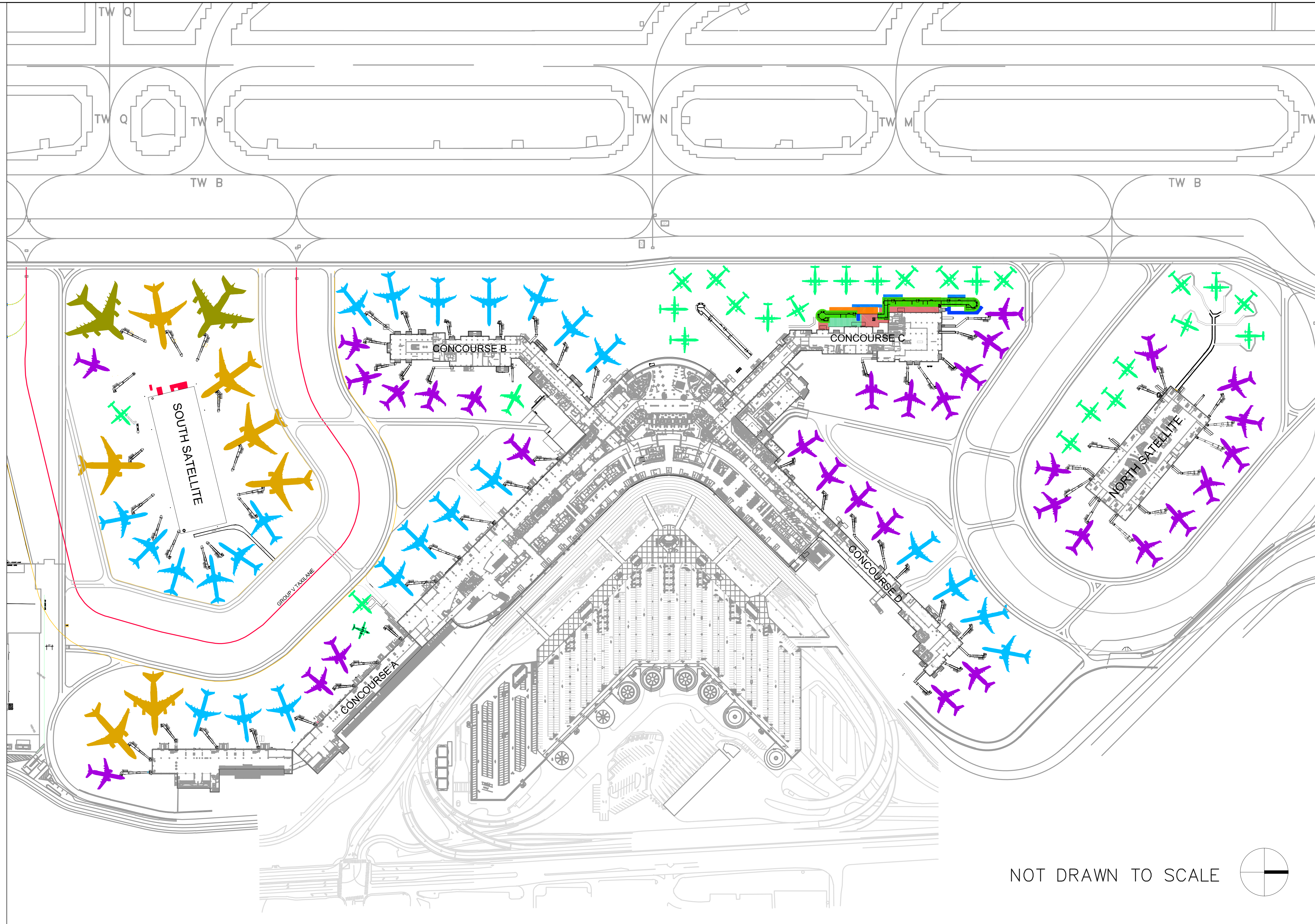


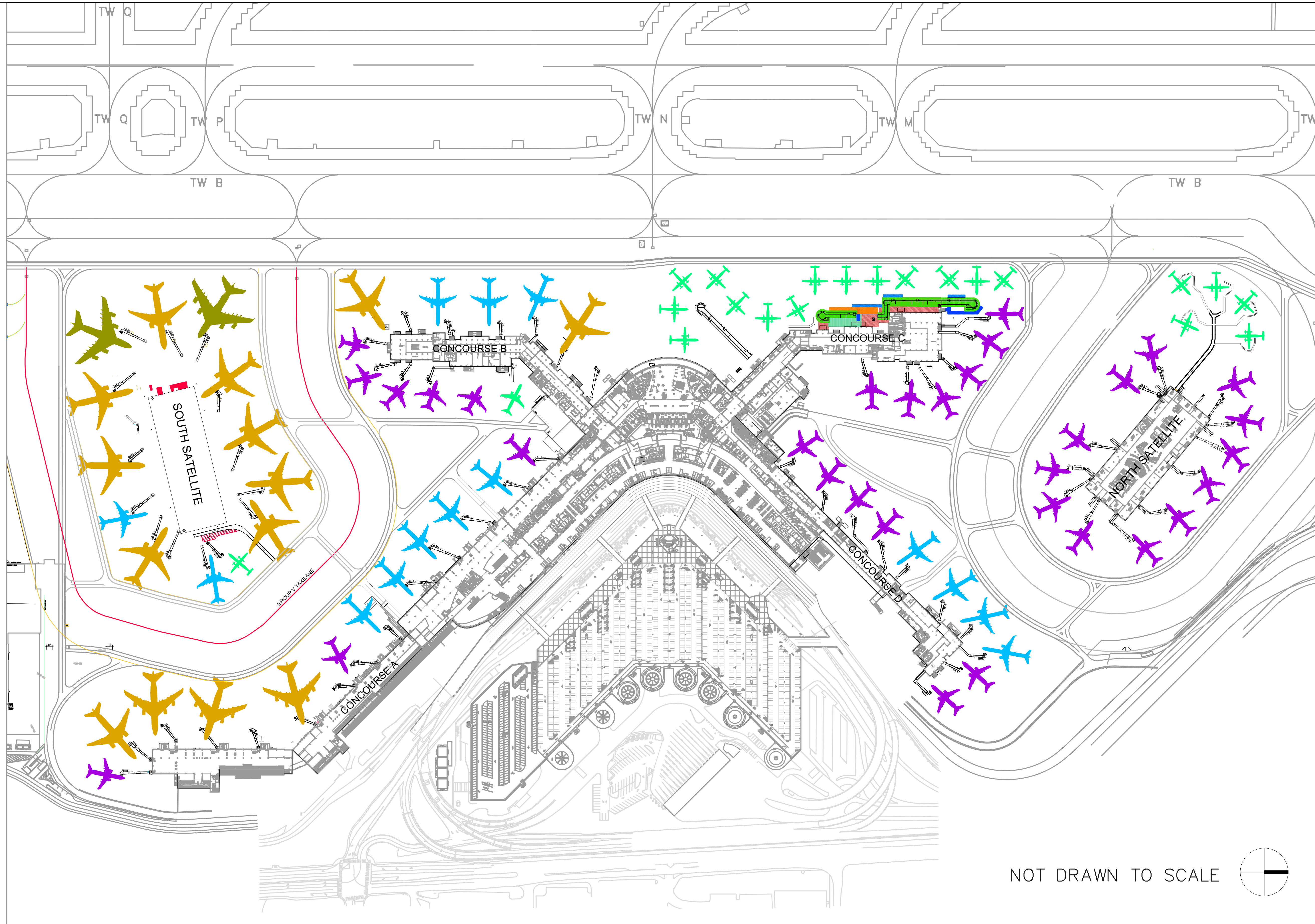
FIGURE 1 – ILLUSTRATION OF MIX A – MAXIMUM AIRCRAFT MIX

LEGEND

- Jet VI
- Jet V
- Jet IV
- Jet III
- Jet RJ/P

Location	Aircraft size category					Total
	RJ/TP	Jet III	Jet IV	Jet V	Jet VI	
International						
South Satellite	1	-	2	8	2	13
Domestic						
Concourse A		3	5	4		12
Concourse B	1	5	3	2		11
Concourse C	14	6				20
Concourse D		6	4			10
North Satellite	5	12				17
Subtotal	20	32	12	6	-	70
TOTAL GATES	21	32	14	14	2	83

Note: The number of aircraft that can be accommodated on the available ramp varies based on factors including facilities, operating practice, and aircraft mix. "Mix B" represents a lower bound of the number of aircraft assuming a maximum number of wide body aircraft.



Sustainable Airport Master Plan
Seattle-Tacoma International Airport

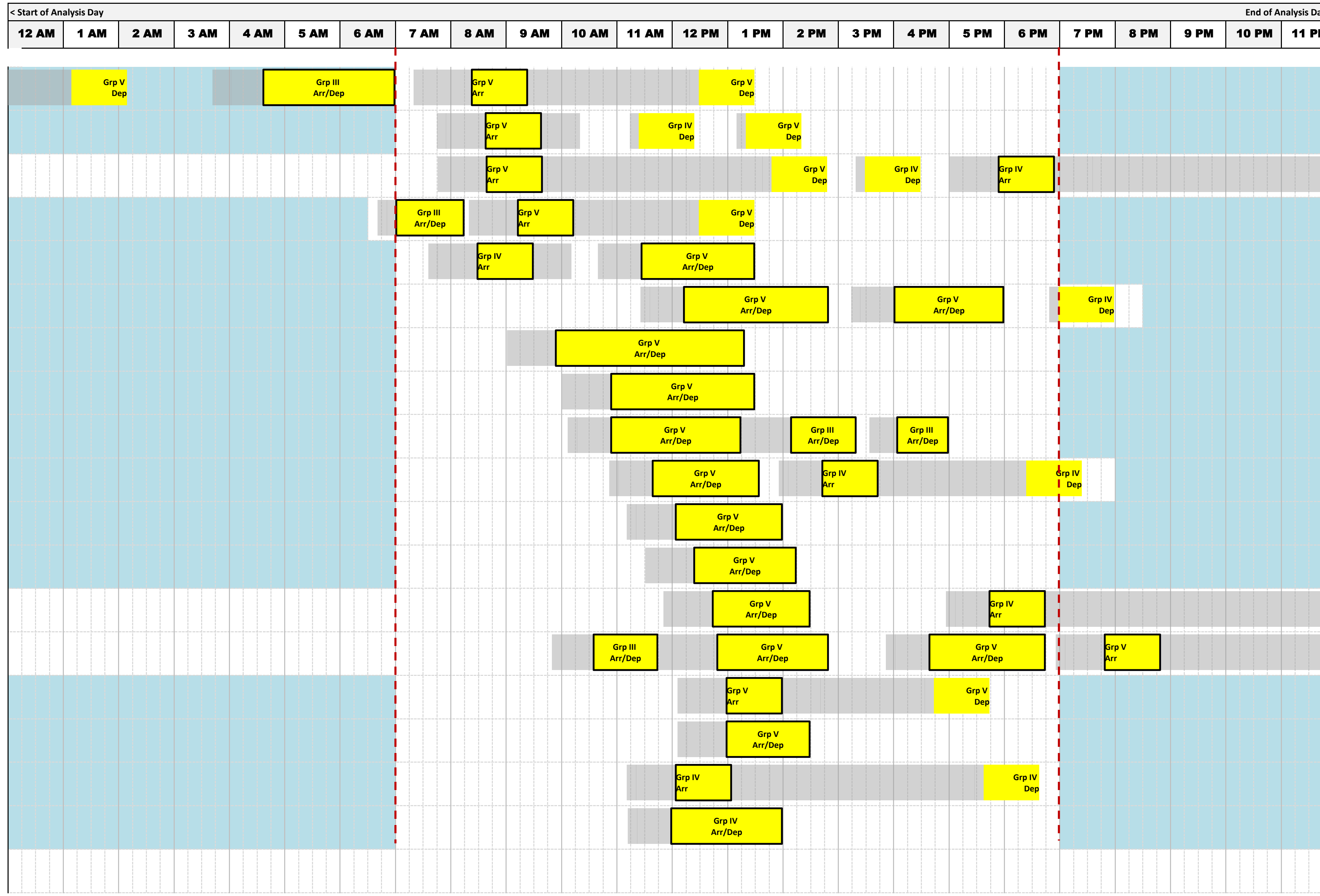
FIGURE 2 – ILLUSTRATION OF MIX B – MAXIMUM WIDEBODY MIX

TECHNICAL MEMORANDUM NO.1 – INVENTORY
JUNE 2015

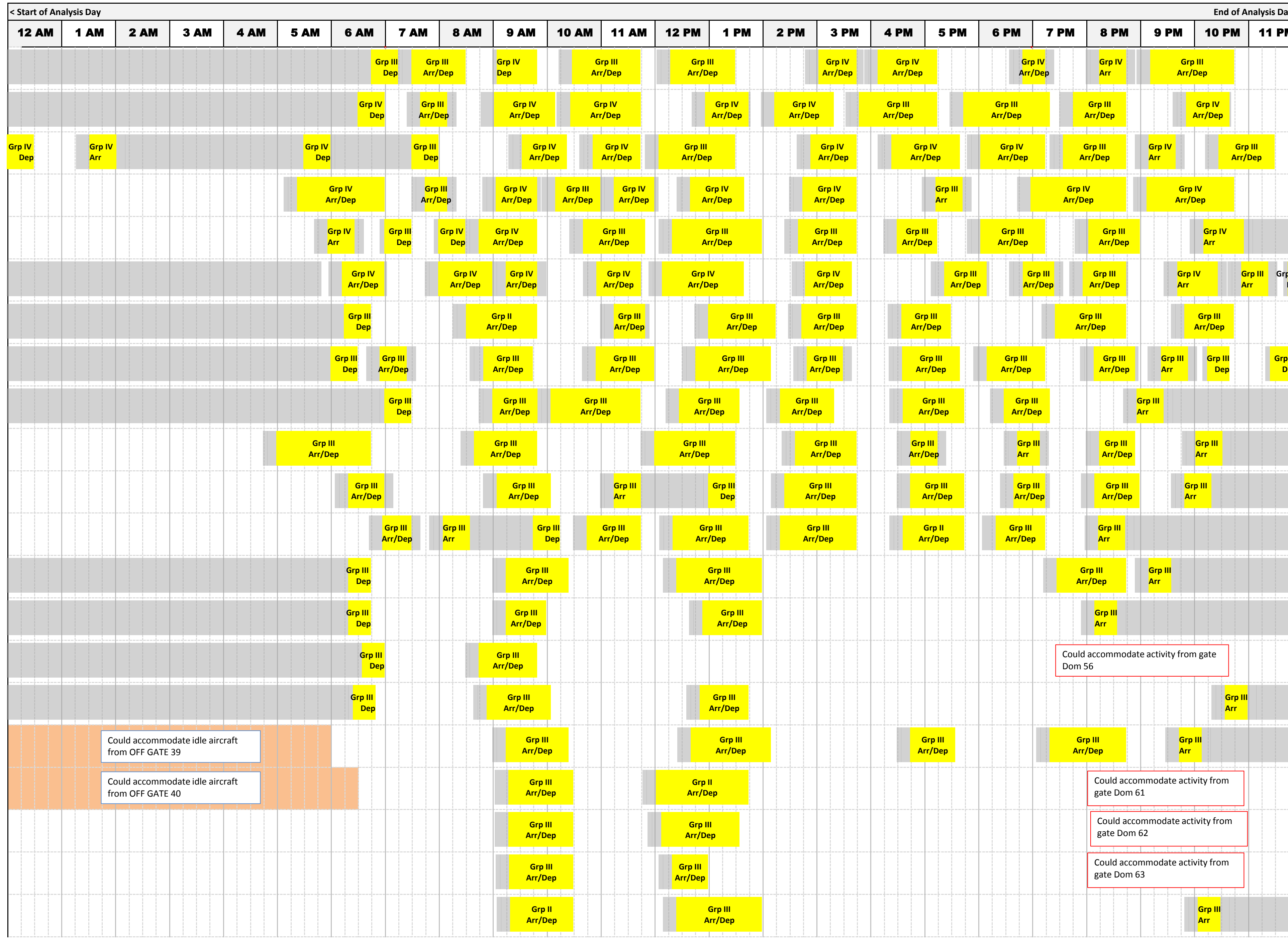
APPENDICES

2019 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Arr + Dep	Turns
INT 1	Existing	V	1	B-777-300ER		5	2.5
INT 2	Existing	V	2	B-777-300ER		3	1.5
INT 3	Existing	V	3	B-777-300ER		4	2
INT 4	Existing	V	4	B-777-300ER		4	2
INT 5	Existing	V	5	B-777-300ER		3	1.5
INT 6	Existing	V	6	B-777-300ER		5	2.5
INT 7	Existing	V	7	B-777-300ER		2	1
INT 8	Existing	V	8	B-777-300ER		2	1
INT 9	Existing	V	9	B-777-300ER		6	3
INT 10	Existing	V	10	B-777-300ER		4	2
INT 11	New			B-777-300ER		2	1
INT 12	New			B-777-300ER		2	1
INT 13	New			B-777-300ER		3	1.5
INT 14	New			B-777-300ER		7	3.5
INT 15	New			B-777-300ER		2	1
INT 16	New			B-777-300ER		2	1
INT 17	Existing	IV	1	B-767-300ERWL		2	1
INT 18	Existing	IV	2	B-767-300ERWL		2	1

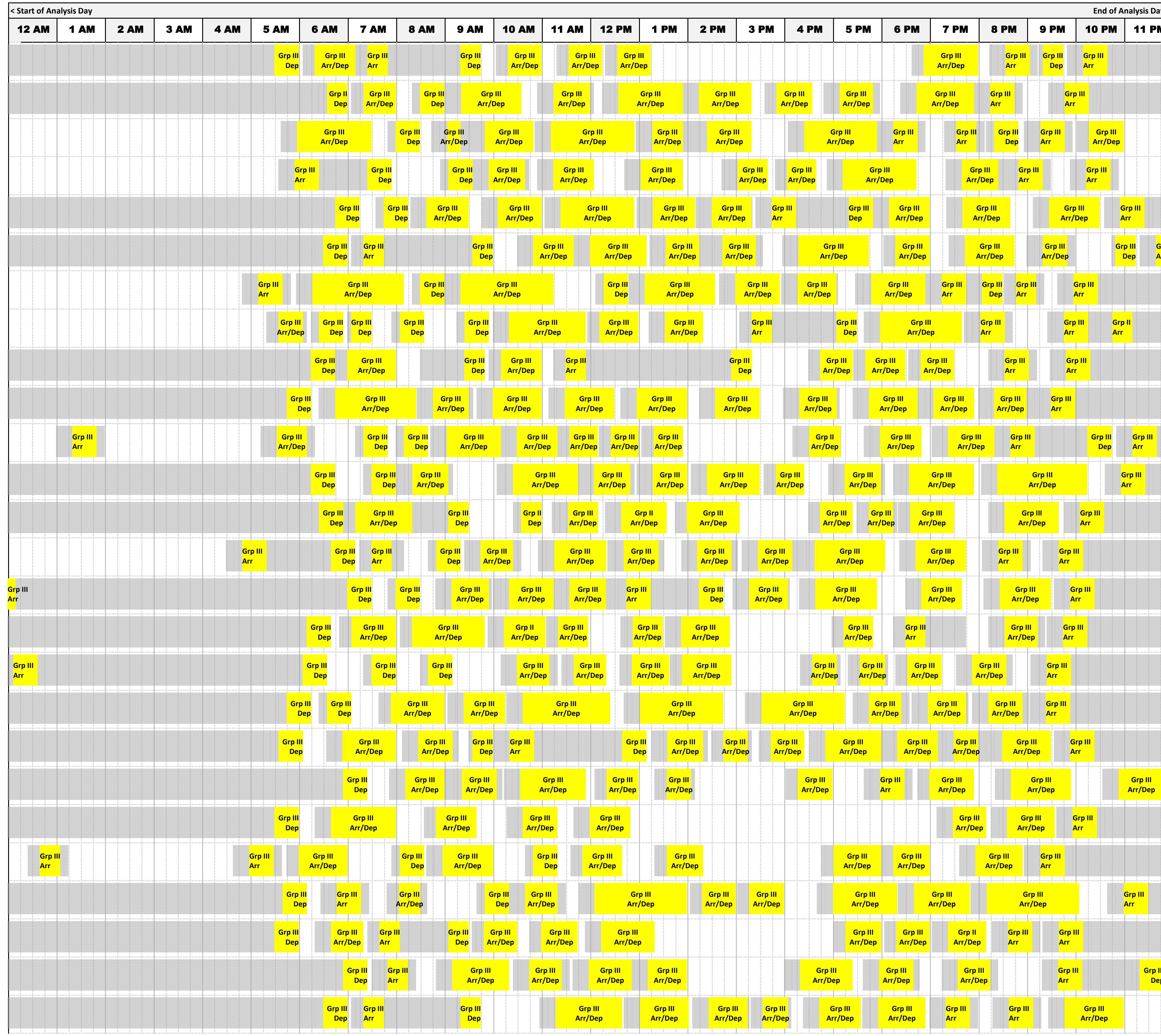


2019 Ramp Chart



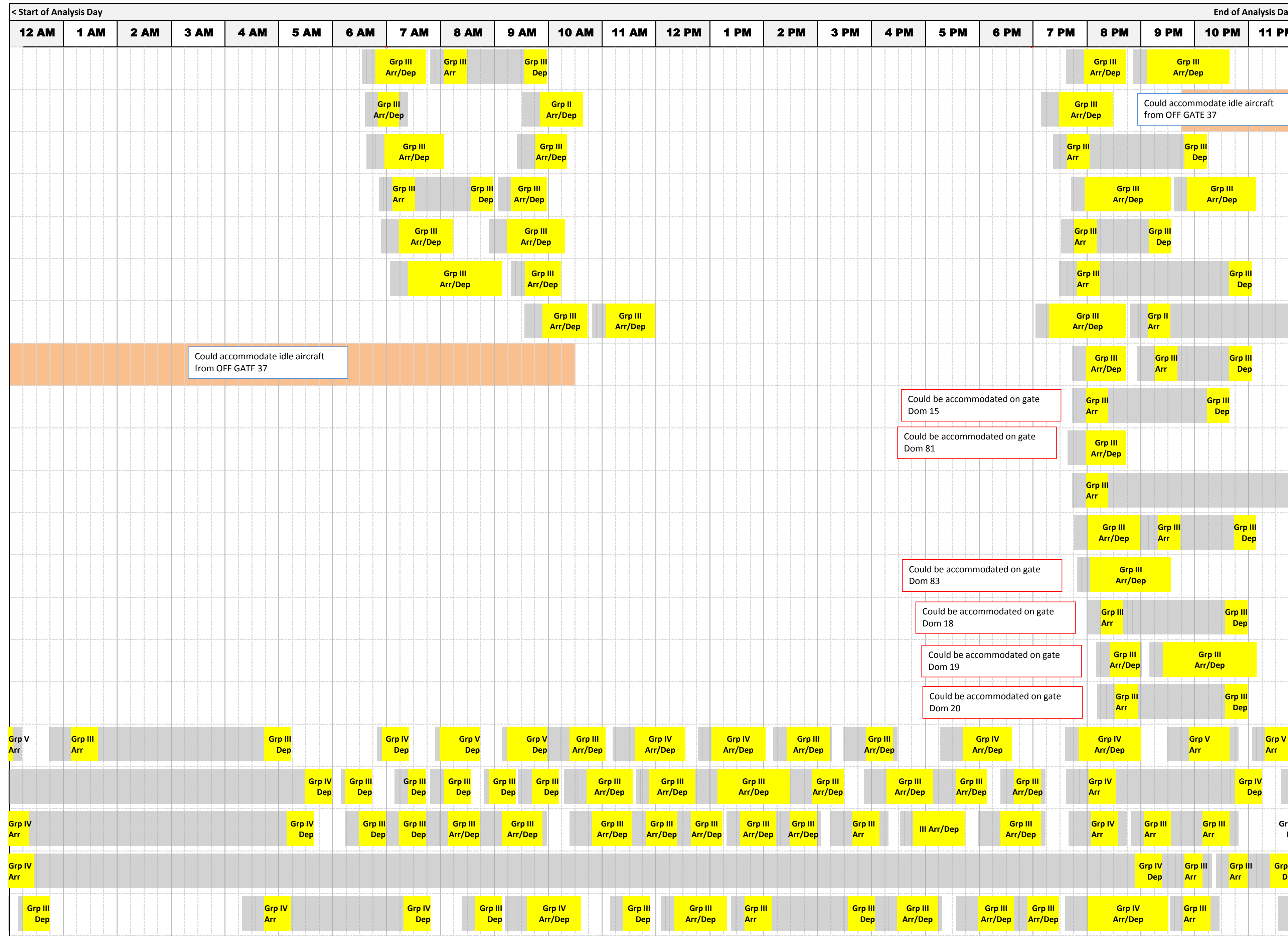
Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Arr + Dep	Turns
DOM 1	Existing	IV	1	B-767-300ERWL		17	8.5
DOM 2	Existing	IV	2	B-767-300ERWL		19	9.5
DOM 3	Existing	IV	3	B-767-300ERWL		21	10.5
DOM 4	Existing	IV	4	B-767-300ERWL		19	9.5
DOM 5	Existing	IV	5	B-767-300ERWL		18	9
DOM 6	Existing	IV	6	B-767-300ERWL		21	10.5
DOM 7	Existing	III	1	B-737-900WL	MD-80	15	7.5
DOM 8	Existing	III	2	B-737-900WL	MD-80	20	10
DOM 9	Existing	III	3	B-737-900WL	MD-80	14	7
DOM 10	Existing	III	4	B-737-900WL	MD-80	14	7
DOM 11	Existing	III	5	B-737-900WL	MD-80	15	7.5
DOM 12	Existing	III	6	B-737-900WL	MD-80	15	7.5
DOM 13	Existing	RJ	1	E-190	CRJ-900	8	4
DOM 14	Existing	RJ	2	E-190	CRJ-900	6	3
DOM 15	Existing	RJ	3	E-190	CRJ-900	3	1.5
DOM 16	Existing	RJ	4	E-190	CRJ-900	6	3
DOM 17	Existing	RJ	5	E-190	CRJ-900	9	4.5
DOM 18	Existing	RJ	6	E-190	CRJ-900	4	2
DOM 19	Existing	RJ	7	E-190	CRJ-900	4	2
DOM 20	Existing	RJ	8	E-190	CRJ-900	4	2
DOM 21	Existing	RJ	9	E-190	CRJ-900	5	2.5

2019 Ramp Chart



Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Arr + Dep	Turns
DOM 22	Existing	III	7	B-737-900WL	MD-80	16	8
DOM 23	Existing	III	8	B-737-900WL	MD-80	20	10
DOM 24	Existing	III	9	B-737-900WL	MD-80	21	10.5
DOM 25	Existing	III	10	B-737-900WL	MD-80	19	9.5
DOM 26	Existing	III	11	B-737-900WL	MD-80	21	10.5
DOM 27	Existing	III	12	B-737-900WL	MD-80	21	10.5
DOM 28	Existing	III	13	B-737-900WL	MD-80	19	9.5
DOM 29	Existing	III	14	B-737-900WL	MD-80	19	9.5
DOM 30	Existing	III	15	B-737-900WL	MD-80	16	8
DOM 31	Existing	III	16	B-737-900WL	MD-80	22	11
DOM 32	Existing	III	17	B-737-900WL	MD-80	24	12
DOM 33	Existing	III	18	B-737-900WL	MD-80	21	10.5
DOM 34	Existing	III	19	B-737-900WL	MD-80	20	10
DOM 35	Existing	III	20	B-737-900WL	MD-80	20	10
DOM 36	Existing	III	21	B-737-900WL	MD-80	20	10
DOM 37	Existing	III	22	B-737-900WL	MD-80	19	9.5
DOM 38	Existing	III	23	B-737-900WL	MD-80	21	10.5
DOM 39	Existing	III	24	B-737-900WL	MD-80	19	9.5
DOM 40	Existing	III	25	B-737-900WL	MD-80	23	11.5
DOM 41	Existing	III	26	B-737-900WL	MD-80	20	10
DOM 42	Existing	III	27	B-737-900WL	MD-80	14	7
DOM 43	Existing	III	28	B-737-900WL	MD-80	19	9.5
DOM 44	Existing	III	29	B-737-900WL	MD-80	20	10
DOM 45	Existing	III	30	B-737-900WL	MD-80	19	9.5
DOM 46	Existing	III	31	B-737-900WL	MD-80	18	9
DOM 47	Existing	III	32	B-737-900WL	MD-80	19	9.5

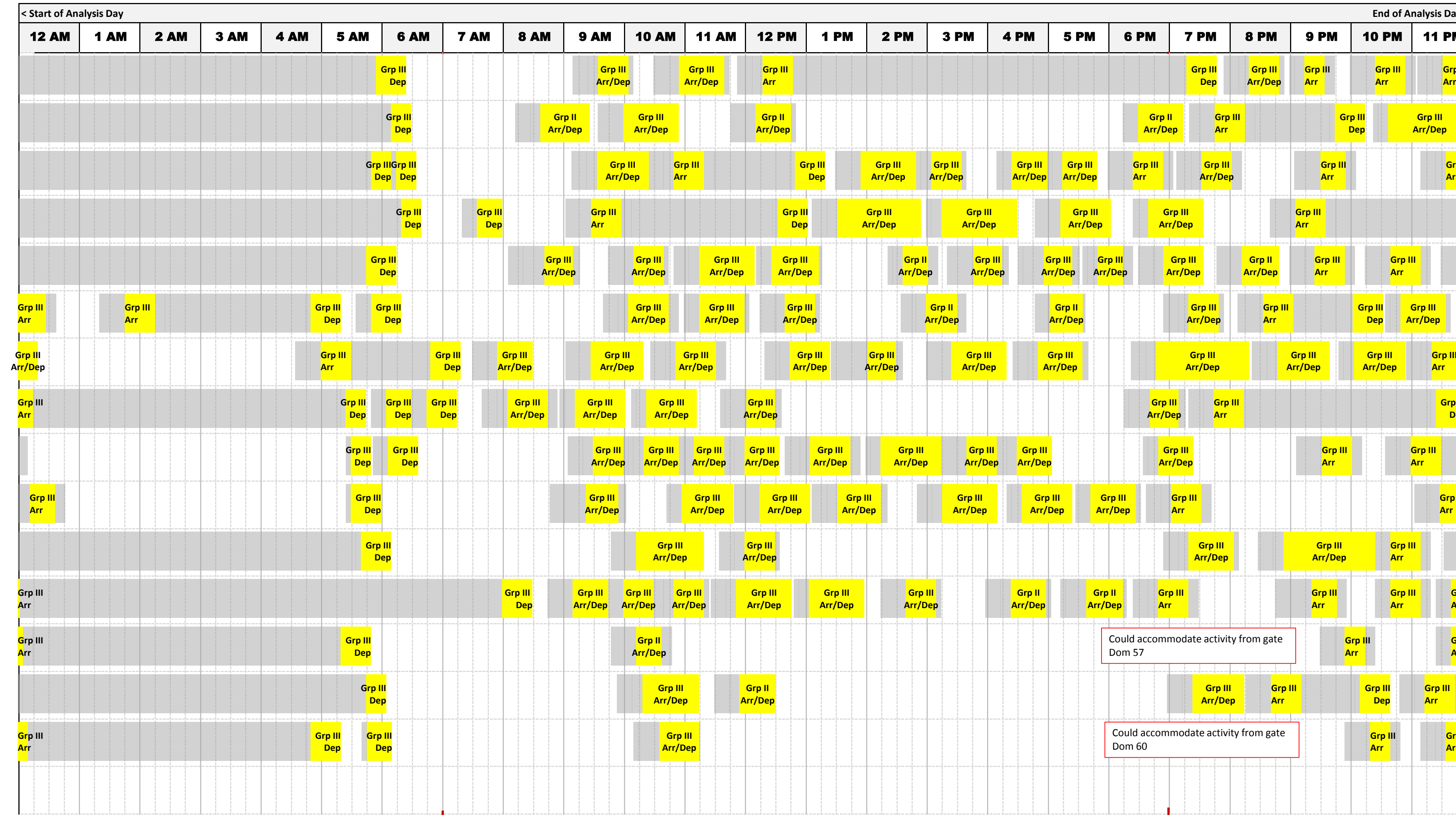
2019 Ramp Chart



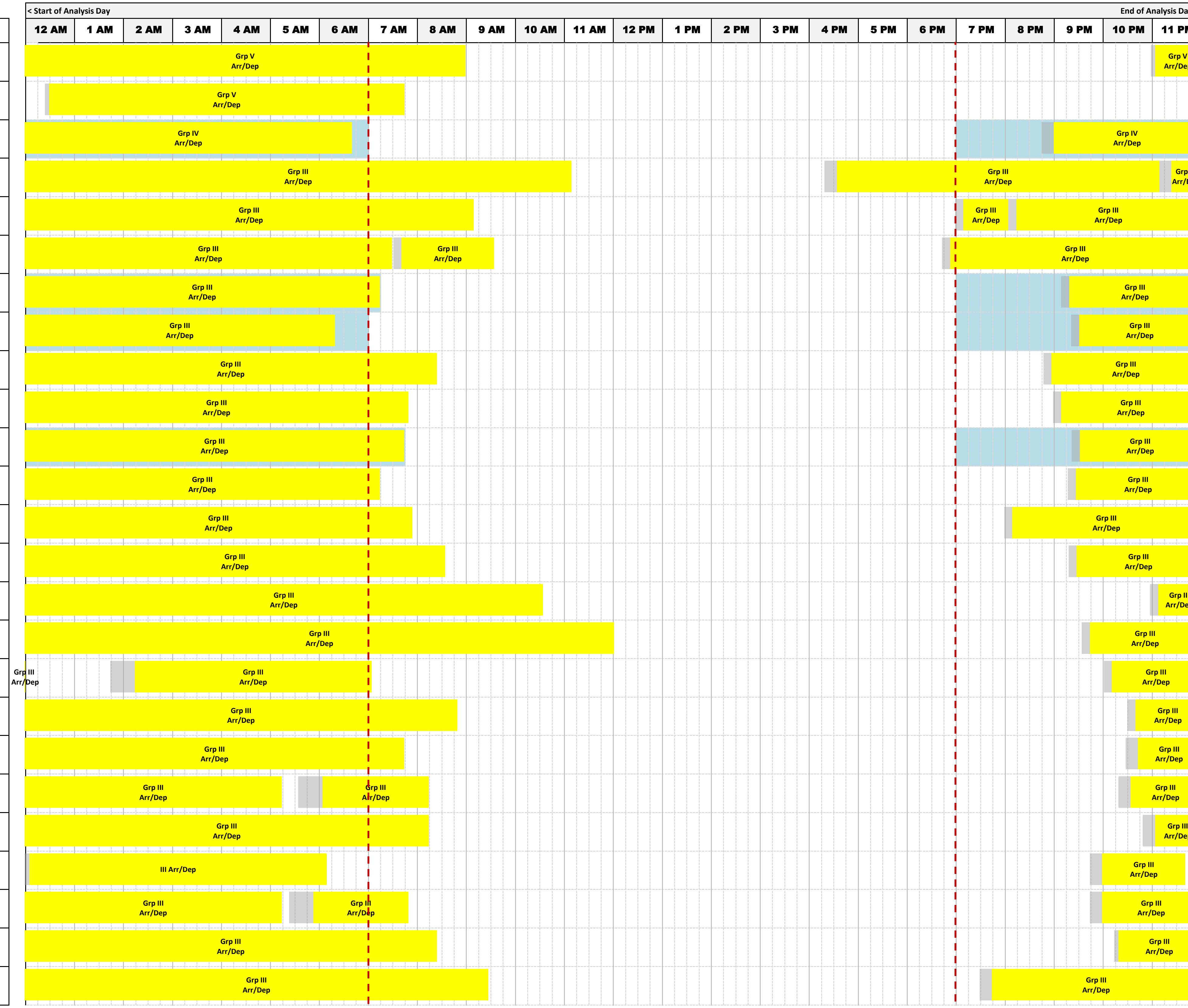
Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Arr + Dep	Turns
DOM 48	Existing	RJ	10	E-190	CRJ-900	8	4
DOM 49	Existing	RJ	11	E-190	CRJ-900	6	3
DOM 50	Existing	RJ	12	E-190	CRJ-900	6	3
DOM 51	Existing	RJ	13	E-190	CRJ-900	8	4
DOM 52	Existing	RJ	14	E-190	CRJ-900	6	3
DOM 53	Existing	RJ	15	E-190	CRJ-900	6	3
DOM 54	Existing	RJ	16	E-190	CRJ-900	7	3.5
DOM 55	Existing	RJ	17	E-190	CRJ-900	4	2
DOM 56	Not Needed			E-190	CRJ-900	2	1
DOM 57	Not Needed			E-190	CRJ-900	2	1
DOM 58	Existing	RJ	18	E-190	CRJ-900	1	0.5
DOM 59	Existing	RJ	19	E-190	CRJ-900	4	2
DOM 60	Not Needed			E-190	CRJ-900	2	1
DOM 61	Not Needed			E-190	CRJ-900	2	1
DOM 62	Not Needed			E-190	CRJ-900	4	2
DOM 63	Not Needed			E-190	CRJ-900	2	1
DOM 64	Existing	V	1	B-777-300ER		22	11
DOM 65	Existing	IV	7	B-767-300ERWL		23	11.5
DOM 66	Existing	IV	8	B-767-300ERWL		27	13.5
DOM 67	Existing	IV	9	B-767-300ERWL		5	2.5
DOM 68	Existing	IV	10	B-767-300ERWL		21	10.5

2019 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Arr + Dep	Turns
DOM 69	Existing	III	33	B-737-900WL	MD-80	12	6
DOM 70	Existing	III	34	B-737-900WL	MD-80	13	6.5
DOM 71	Existing	III	35	B-737-900WL	MD-80	19	9.5
DOM 72	Existing	III	36	B-737-900WL	MD-80	13	6.5
DOM 73	Existing	III	37	B-737-900WL	MD-80	24	12
DOM 74	Existing	III	38	B-737-900WL	MD-80	20	10
DOM 75	Existing	III	39	B-737-900WL	MD-80	25	12.5
DOM 76	New			B-737-900WL	MD-80	16	8
DOM 77	New			B-737-900WL	MD-80	22	11
DOM 78	New			B-737-900WL	MD-80	18	9
DOM 79	New			B-737-900WL	MD-80	11	5.5
DOM 80	New			B-737-900WL	MD-80	22	11
DOM 81	New			B-737-900WL	MD-80	6	3
DOM 82	New			B-737-900WL	MD-80	10	5
DOM 83	New			B-737-900WL	MD-80	7	3.5



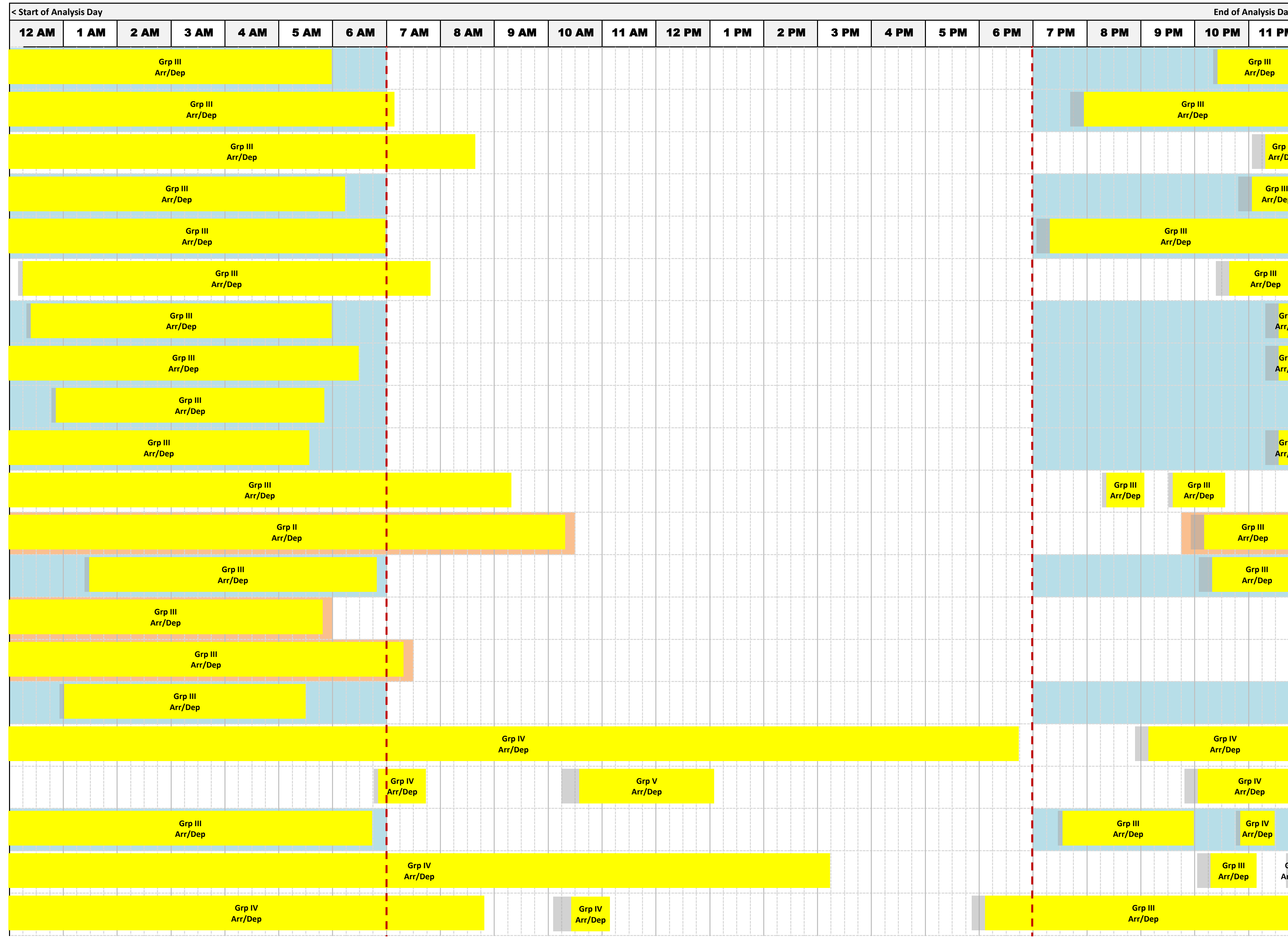
2019 Ramp Chart



Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Arr + Dep	Turns
OFF GATE 1	RON Offgate			B-777-300ER		2	1
OFF GATE 2	RON Offgate			B-777-300ER		2	1
OFF GATE 3	RON FIS Gate			B-767-300ERWL		2	1
OFF GATE 4	RON Offgate			B-767-300ERWL		4	2
OFF GATE 5	RON Offgate			B-737-900WL	MD-80	4	2
OFF GATE 6	RON Offgate			B-737-900WL	MD-80	4	2
OFF GATE 7	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 8	RON FIS Gate			B-737-900WL	MD-80	2	1
OFF GATE 9	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 10	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 11	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 12	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 13	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 14	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 15	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 16	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 17	RON Offgate			B-737-900WL	MD-80	3	1.5
OFF GATE 18	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 19	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 20	RON Offgate			B-737-900WL	MD-80	4	2
OFF GATE 21	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 22	RON Offgate			B-737-900WL	MD-80	4	2
OFF GATE 23	RON Offgate			B-737-900WL	MD-80	4	2
OFF GATE 24	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 25	RON Offgate			B-737-900WL	MD-80	2	1

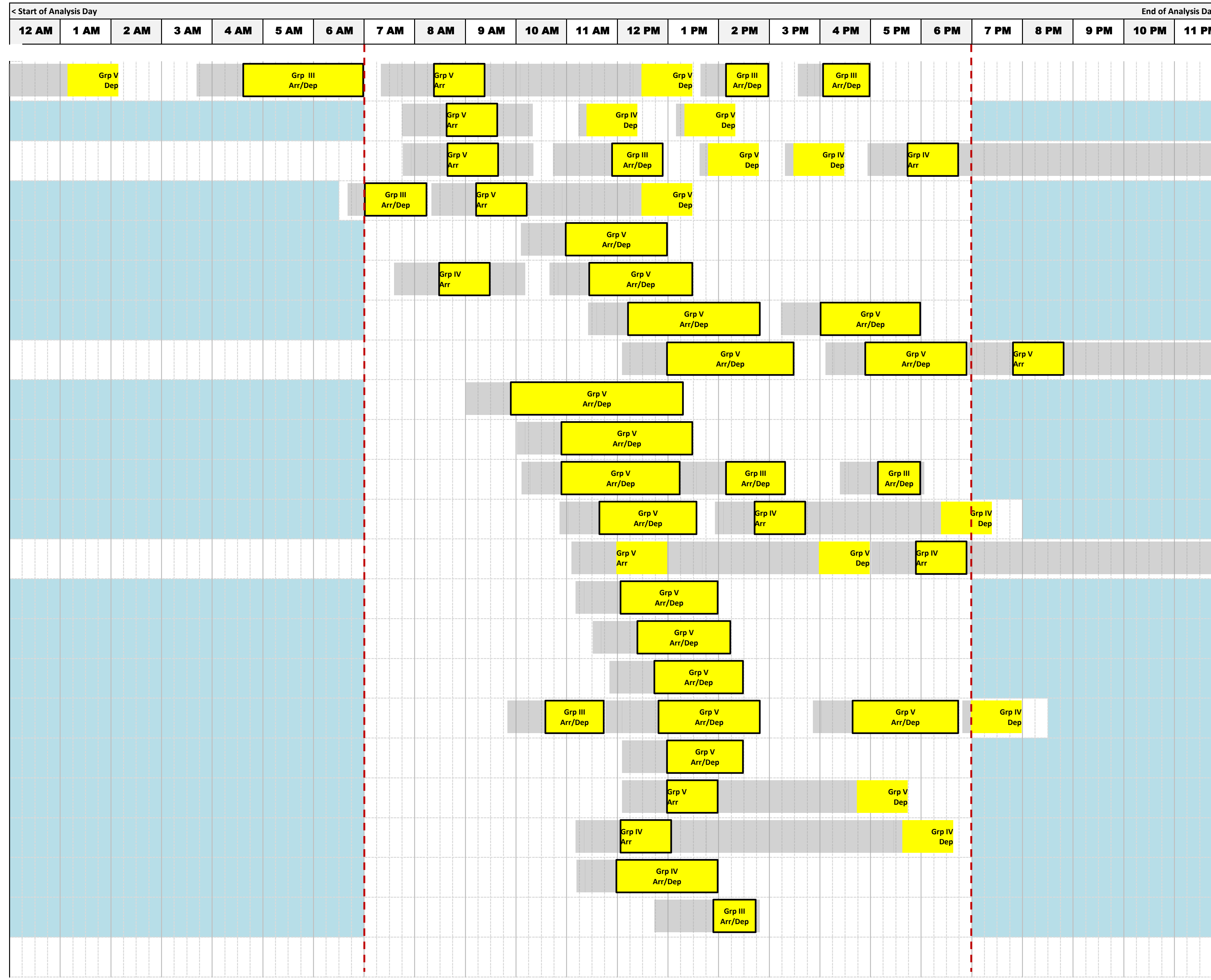
2019 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Arr + Dep	Turns
OFF GATE 26	RON FIS Gate			B-737-900WL	MD-80	2	1
OFF GATE 27	RON FIS Gate			B-737-900WL	MD-80	2	1
OFF GATE 28	RON Offgate			B-737-900WL	MD-80	2	1
OFF GATE 29	RON FIS Gate			B-737-900WL	MD-80	2	1
OFF GATE 30	RON FIS Gate			B-737-900WL	MD-80	2	1
OFF GATE 31	RON Offgate			B-737-900WL	MD-80	3	1.5
OFF GATE 32	RON FIS Gate			B-737-900WL	MD-80	3	1.5
OFF GATE 33	RON FIS Gate			B-737-900WL	MD-80	2	1
OFF GATE 34	RON FIS Gate			B-737-900WL	MD-80	2	1
OFF GATE 35	RON FIS Gate			B-737-900WL	MD-80	2	1
OFF GATE 36	RON Offgate			E-190	CRJ-900	5	2.5
OFF GATE 37	RON Offgate			E-190	CRJ-900	2	1
OFF GATE 38	RON Offgate			E-190	CRJ-900	3	1.5
OFF GATE 39	RON Offgate			E-190	CRJ-900	1	0.5
OFF GATE 40	RON Offgate			E-190	CRJ-900	1	0.5
OFF GATE 41	RON Offgate			E-190	CRJ-900	2	1
OFF GATE 42	RON Offgate			B-777-300ER		2	1
OFF GATE 43	RON Offgate			B-777-300ER		5	2.5
OFF GATE 44	RON FIS Gate			B-767-300ERWL		5	2.5
OFF GATE 45	RON Offgate			B-767-300ERWL		4	2
OFF GATE 46	RON Offgate			B-767-300ERWL		4	2



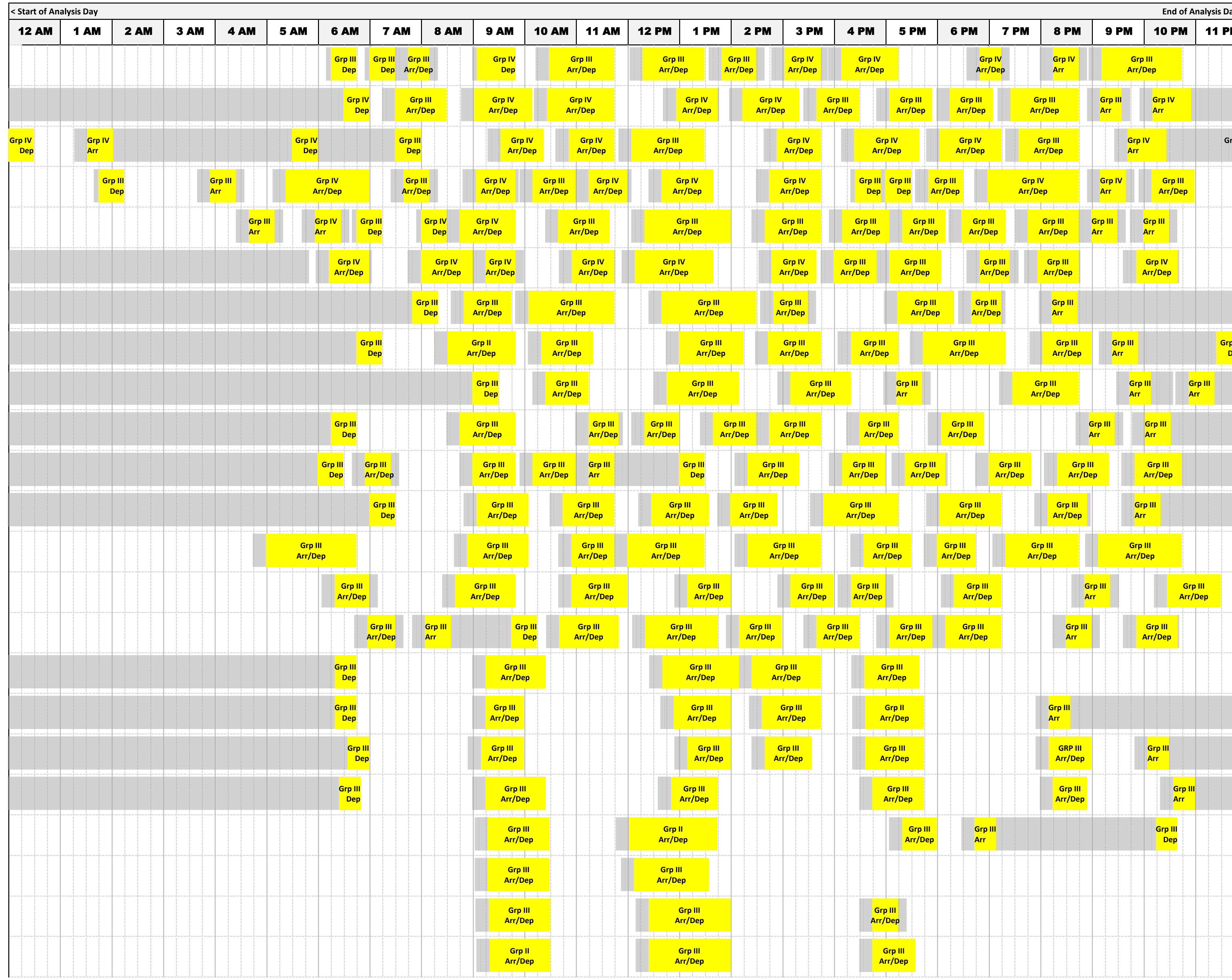
2024 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
INT 1	Existing	V	1	B-777-300ER			9	4.5
INT 2	Existing	V	2	B-777-300ER			3	1.5
INT 3	Existing	V	3	B-777-300ER			6	3
INT 4	Existing	V	4	B-777-300ER			4	2
INT 5	Existing	V	5	B-777-300ER			2	1
INT 6	Existing	V	6	B-777-300ER			3	1.5
INT 7	Existing	V	7	B-777-300ER			4	2
INT 8	Existing	V	8	B-777-300ER			5	2.5
INT 9	Existing	V	9	B-777-300ER			2	1
INT 10	Existing	V	10	B-777-300ER			2	1
INT 11	New			B-777-300ER			6	3
INT 12	New			B-777-300ER			4	2
INT 13	New			B-777-300ER			3	1.5
INT 14	New			B-777-300ER			2	1
INT 15	New			B-777-300ER			2	1
INT 16	New			B-777-300ER			2	1
INT 17	New			B-777-300ER			7	3.5
INT 18	New			B-777-300ER			2	1
INT 19	New			B-777-300ER			2	1
INT 20	Existing	IV	1	B-767-300ERWL			2	1
INT 21	Existing	IV	2	B-767-300ERWL			2	1
INT 22	New			B-737-900WL	MD-80		2	1

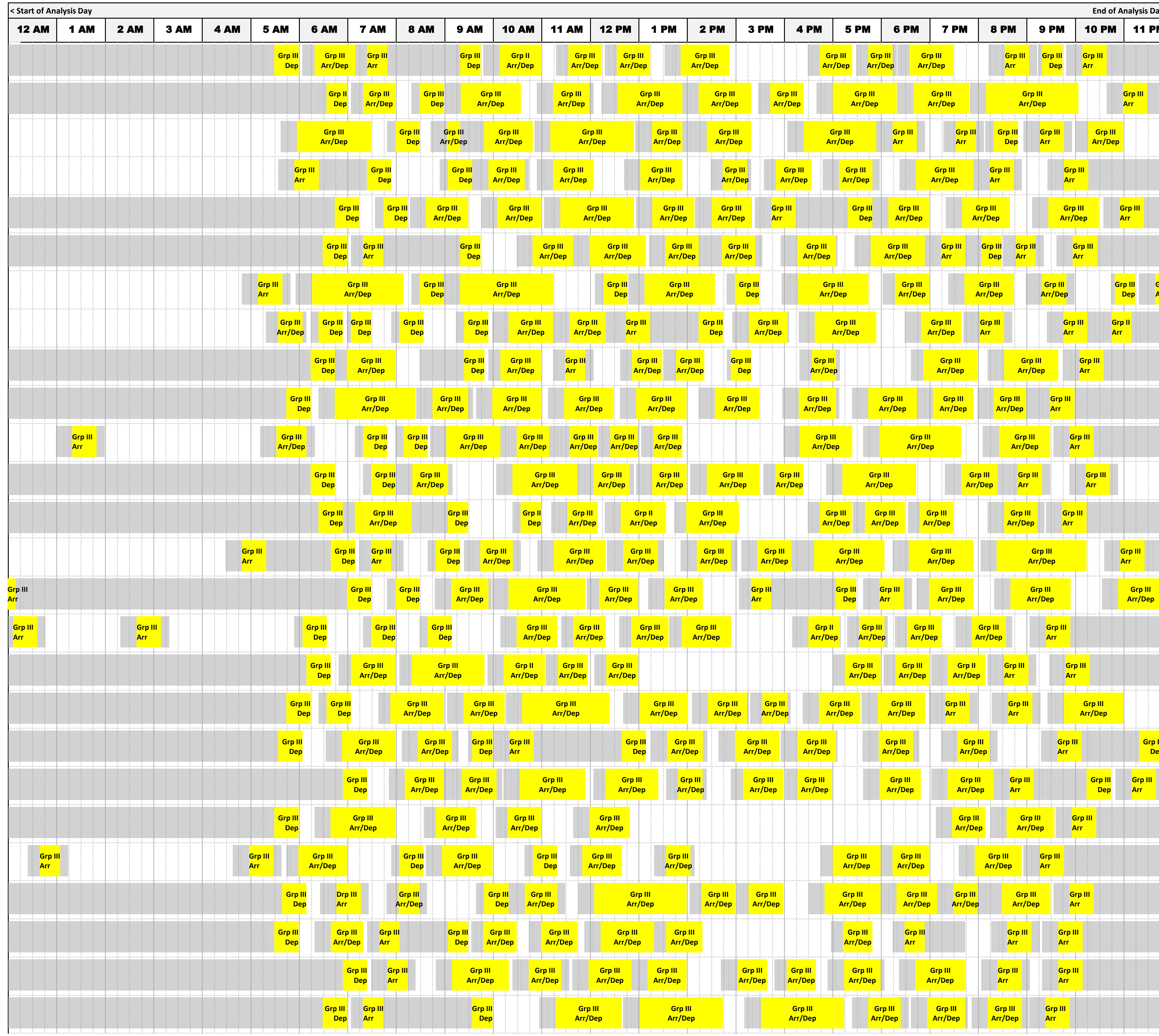


2024 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 1	Existing	IV	1	B-767-300ERWL			20	10
DOM 2	Existing	IV	2	B-767-300ERWL			21	10.5
DOM 3	Existing	IV	3	B-767-300ERWL			20	10
DOM 4	Existing	IV	4	B-767-300ERWL			25	12.5
DOM 5	Existing	IV	5	B-767-300ERWL			22	11
DOM 6	Existing	IV	6	B-767-300ERWL			22	11
DOM 7	Existing	III	1	B-737-900WL	MD-80		14	7
DOM 8	Existing	III	2	B-737-900WL	MD-80		17	8.5
DOM 9	Existing	III	3	B-737-900WL	MD-80		12	6
DOM 10	Existing	III	4	B-737-900WL	MD-80		17	8.5
DOM 11	Existing	III	5	B-737-900WL	MD-80		21	10.5
DOM 12	Existing	III	6	B-737-900WL	MD-80		16	8
DOM 13	Existing	III	7	B-737-900WL	MD-80		18	9
DOM 14	Existing	III	8	B-737-900WL	MD-80		17	8.5
DOM 15	Existing	III	9	B-737-900WL	MD-80		19	9.5
DOM 16	Existing	RJ	1	E-190	CRJ-900		9	4.5
DOM 17	Existing	RJ	2	E-190	CRJ-900		10	5
DOM 18	Existing	RJ	3	E-190	CRJ-900		12	6
DOM 19	Existing	RJ	4	E-190	CRJ-900		10	5
DOM 20	Existing	RJ	5	E-190	CRJ-900		8	4
DOM 21	Existing	RJ	6	E-190	CRJ-900		4	2
DOM 22	Existing	RJ	7	E-190	CRJ-900		6	3
DOM 23	Existing	RJ	8	E-190	CRJ-900		6	3



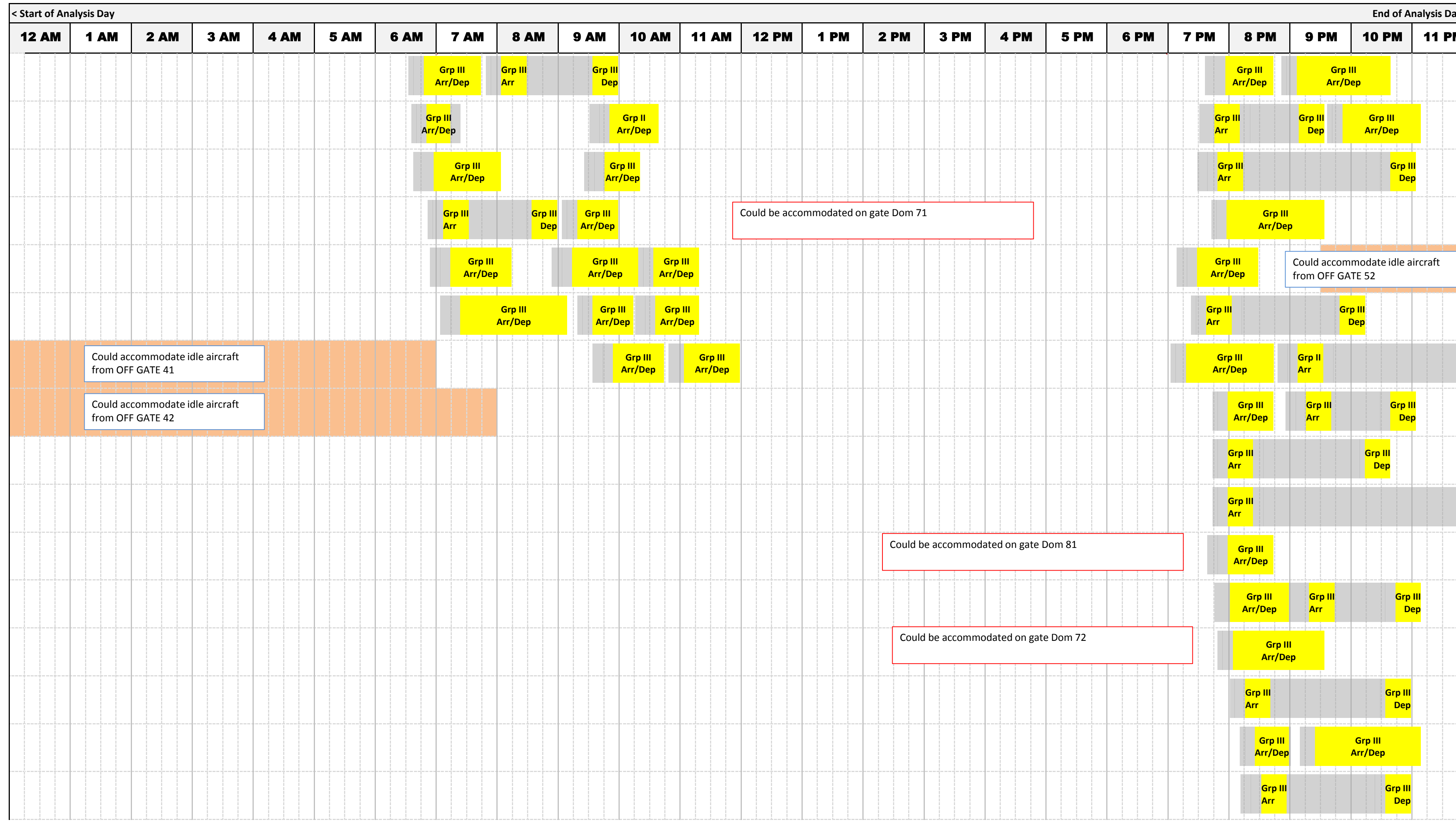
2024 Ramp Chart



Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 24	Existing	III	10	B-737-900WL	MD-80		22	11
DOM 25	Existing	III	11	B-737-900WL	MD-80		21	10.5
DOM 26	Existing	III	12	B-737-900WL	MD-80		21	10.5
DOM 27	Existing	III	13	B-737-900WL	MD-80		19	9.5
DOM 28	Existing	III	14	B-737-900WL	MD-80		21	10.5
DOM 29	Existing	III	15	B-737-900WL	MD-80		19	9.5
DOM 30	Existing	III	16	B-737-900WL	MD-80		20	10
DOM 31	Existing	III	17	B-737-900WL	MD-80		21	10.5
DOM 32	Existing	III	18	B-737-900WL	MD-80		19	9.5
DOM 33	Existing	III	19	B-737-900WL	MD-80		22	11
DOM 34	Existing	III	20	B-737-900WL	MD-80		22	11
DOM 35	Existing	III	21	B-737-900WL	MD-80		20	10
DOM 36	Existing	III	22	B-737-900WL	MD-80		20	10
DOM 37	Existing	III	23	B-737-900WL	MD-80		21	10.5
DOM 38	Existing	III	24	B-737-900WL	MD-80		20	10
DOM 39	Existing	III	25	B-737-900WL	MD-80		22	11
DOM 40	Existing	III	26	B-737-900WL	MD-80		19	9.5
DOM 41	Existing	III	27	B-737-900WL	MD-80		22	11
DOM 42	Existing	III	28	B-737-900WL	MD-80		20	10
DOM 43	Existing	III	29	B-737-900WL	MD-80		22	11
DOM 44	Existing	III	30	B-737-900WL	MD-80		14	7
DOM 45	Existing	III	31	B-737-900WL	MD-80		19	9.5
DOM 46	Existing	III	32	B-737-900WL	MD-80		22	11
DOM 47	Existing	III	33	B-737-900WL	MD-80		18	9
DOM 48	Existing	III	34	B-737-900WL	MD-80		20	10
DOM 49	Existing	III	35	B-737-900WL	MD-80		16	8

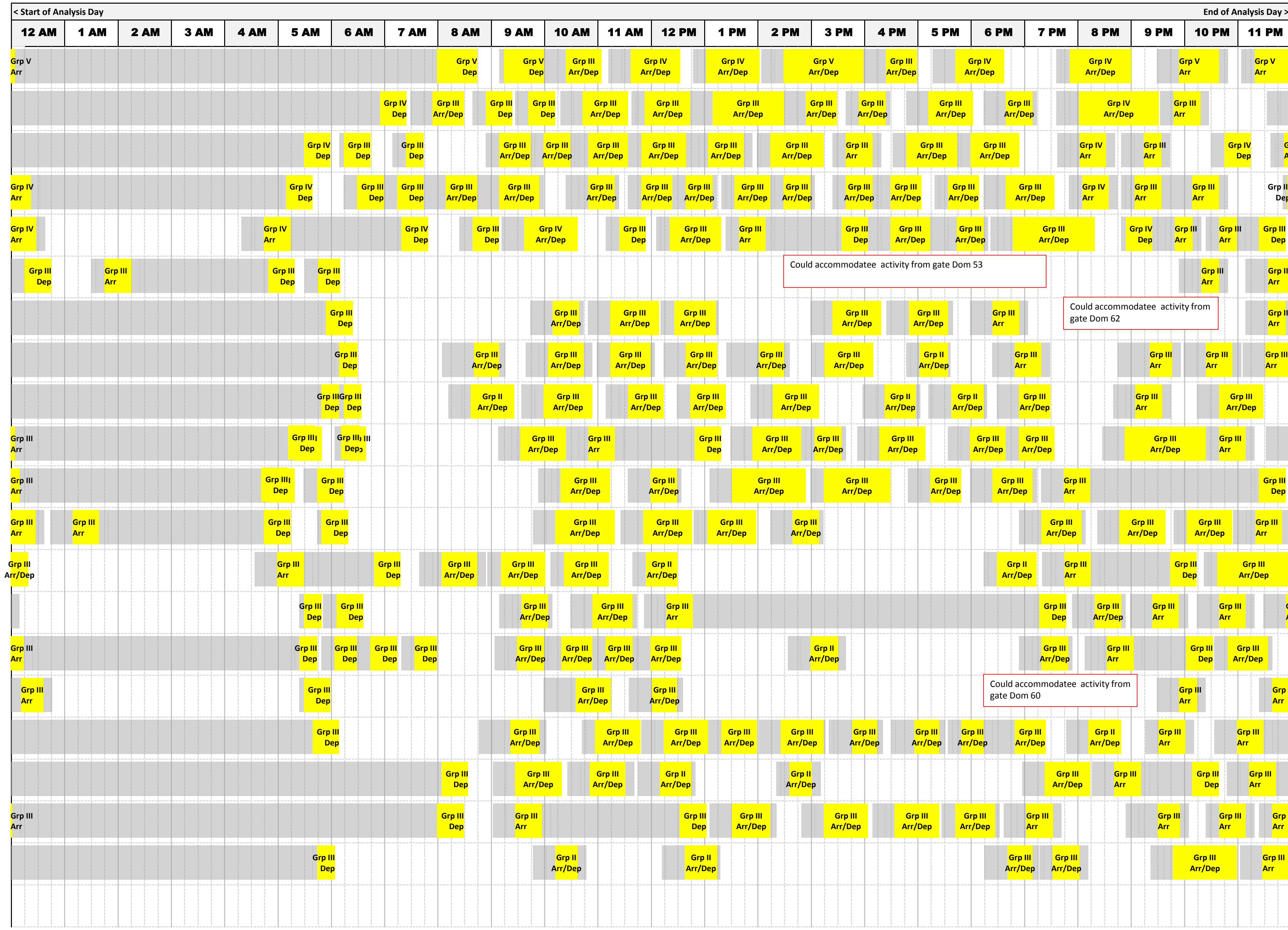
2024 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 50	Existing	RJ	9	E-190	CRJ-900		8	4
DOM 51	Existing	RJ	10	E-190	CRJ-900		8	4
DOM 52	Existing	RJ	11	E-190	CRJ-900		6	3
DOM 53	Not Needed			E-190	CRJ-900		6	3
DOM 54	Existing	RJ	12	E-190	CRJ-900		8	4
DOM 55	Existing	RJ	13	E-190	CRJ-900		8	4
DOM 56	Existing	RJ	14	E-190	CRJ-900		7	3.5
DOM 57	Existing	RJ	15	E-190	CRJ-900		4	2
DOM 58	Existing	RJ	16	E-190	CRJ-900		2	1
DOM 59	Existing	RJ	17	E-190	CRJ-900		1	0.5
DOM 60	Not Needed			E-190	CRJ-900		2	1
DOM 61	Existing	RJ	18	E-190	CRJ-900		4	2
DOM 62	Not Needed			E-190	CRJ-900		2	1
DOM 63	Existing	RJ	19	E-190	CRJ-900		2	1
DOM 64	Existing	RJ	20	E-190	CRJ-900		4	2
DOM 65	New			E-190	CRJ-900		2	1



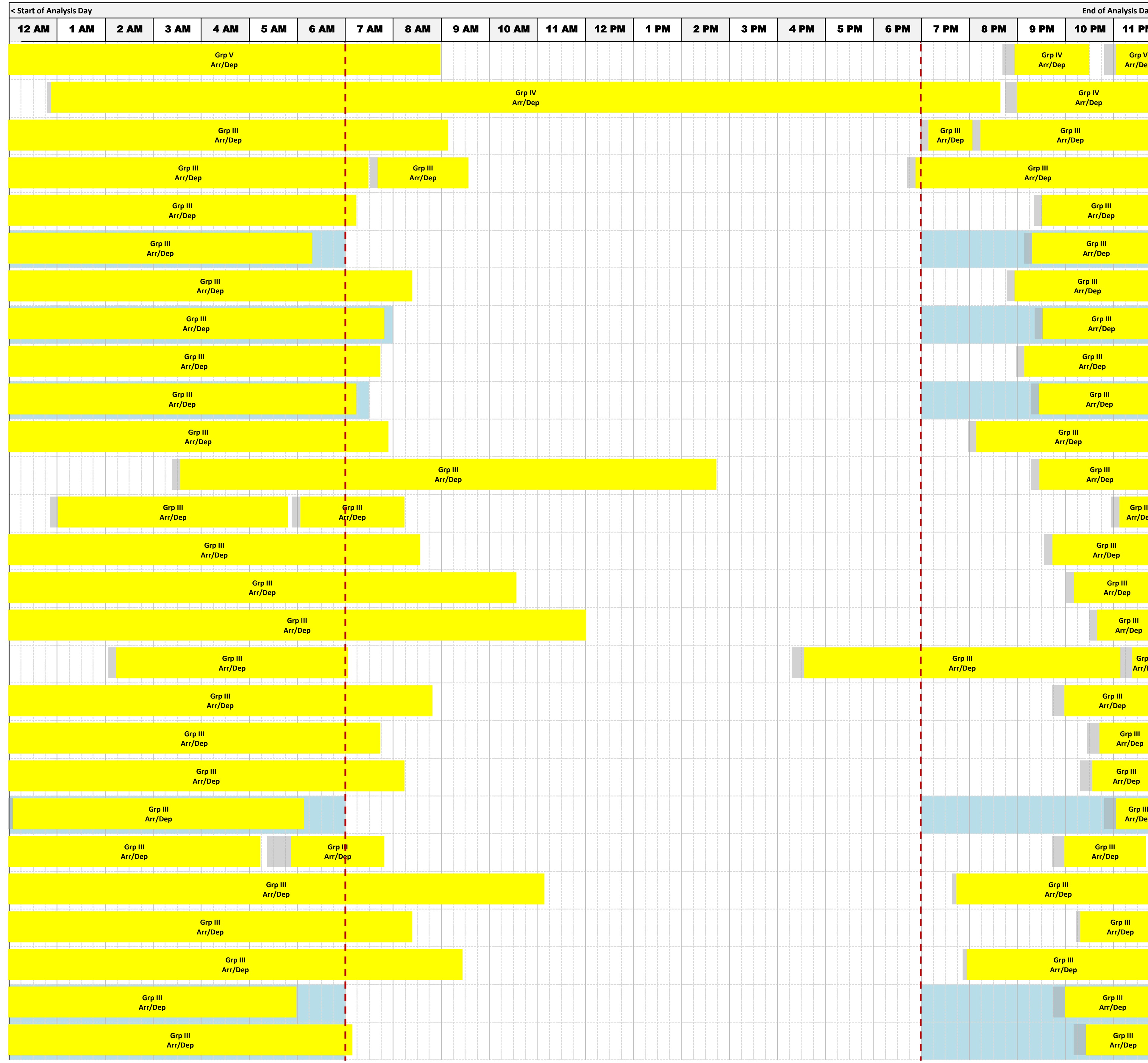
2024 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 66	Existing	V	1	B-777-300ER			19	9.5
DOM 67	Existing	IV	7	B-767-300ERWL			23	11.5
DOM 68	Existing	IV	8	B-767-300ERWL			24	12
DOM 69	Existing	IV	9	B-767-300ERWL			30	15
DOM 70	Existing	IV	10	B-767-300ERWL			21	10.5
DOM 71	Existing	III	36	B-737-900WL	MD-80		6	3
DOM 72	Existing	III	37	B-737-900WL	MD-80		13	6.5
DOM 73	Existing	III	38	B-737-900WL	MD-80		19	9.5
DOM 74	Existing	III	39	B-737-900WL	MD-80		21	10.5
DOM 75	New			B-737-900WL	MD-80		21	10.5
DOM 76	New			B-737-900WL	MD-80		17	8.5
DOM 77	New			B-737-900WL	MD-80		19	9.5
DOM 78	New			B-737-900WL	MD-80		18	9
DOM 79	New			B-737-900WL	MD-80		13	6.5
DOM 80	New			B-737-900WL	MD-80		21	10.5
DOM 81	New			B-737-900WL	MD-80		8	4
DOM 82	New			B-737-900WL	MD-80		23	11.5
DOM 83	New			B-737-900WL	MD-80		14	7
DOM 84	New			B-737-900WL	MD-80		16	8
DOM 85	New			B-737-900WL	MD-80		12	6



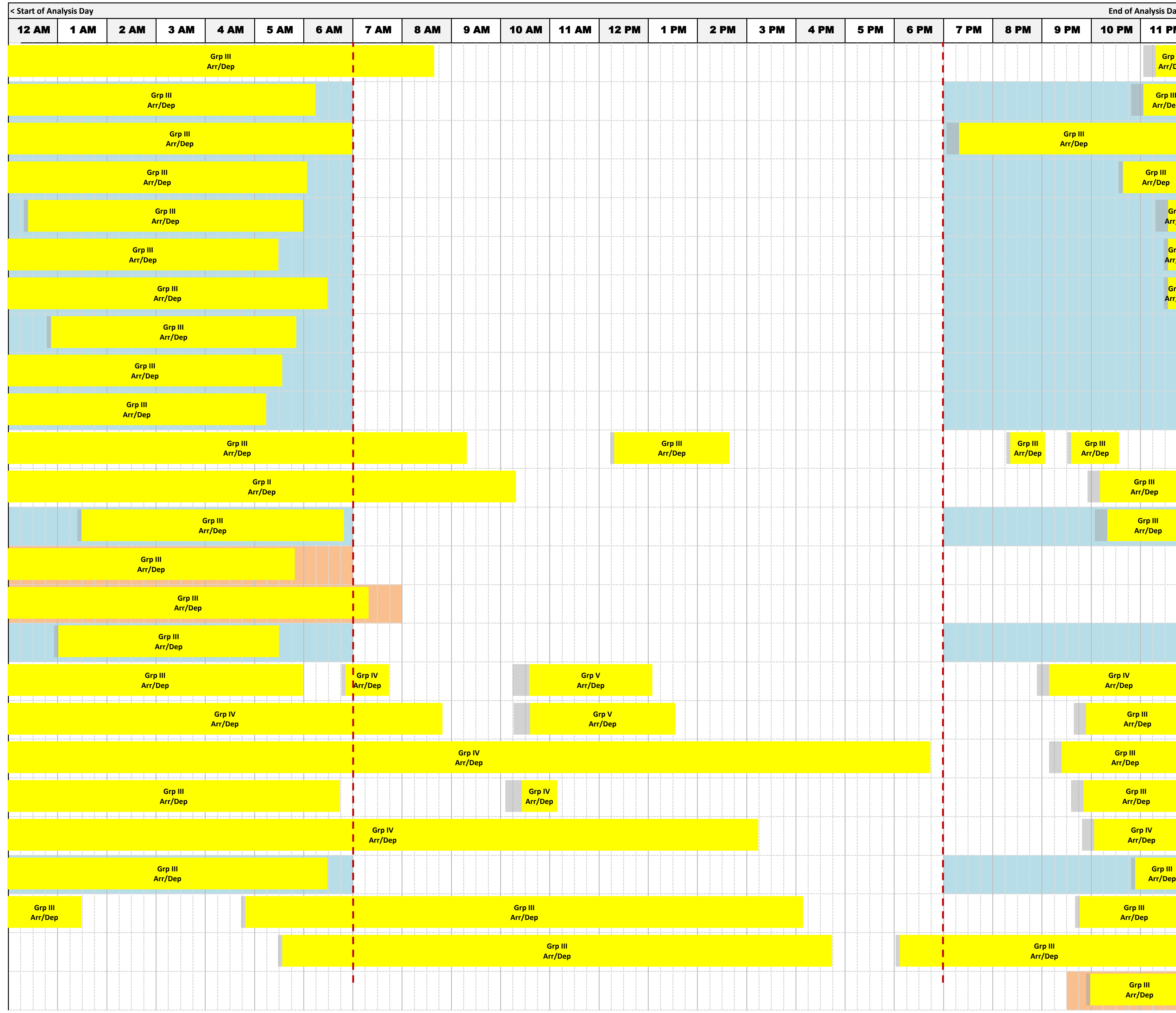
2024 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
OFF GATE 1	RON Offgate			B-777-300ER			4	2
OFF GATE 2	RON Offgate			B-767-300ERWL			3	1.5
OFF GATE 3	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 4	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 5	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 6	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 7	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 8	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 9	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 10	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 11	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 12	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 13	RON Offgate			B-737-900WL	MD-80		5	2.5
OFF GATE 14	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 15	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 16	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 17	RON Offgate			B-737-900WL	MD-80		5	2.5
OFF GATE 18	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 19	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 20	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 21	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 22	RON Offgate			B-737-900WL	MD-80		6	3
OFF GATE 23	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 24	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 25	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 26	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 27	RON FIS gate			B-737-900WL	MD-80		2	1

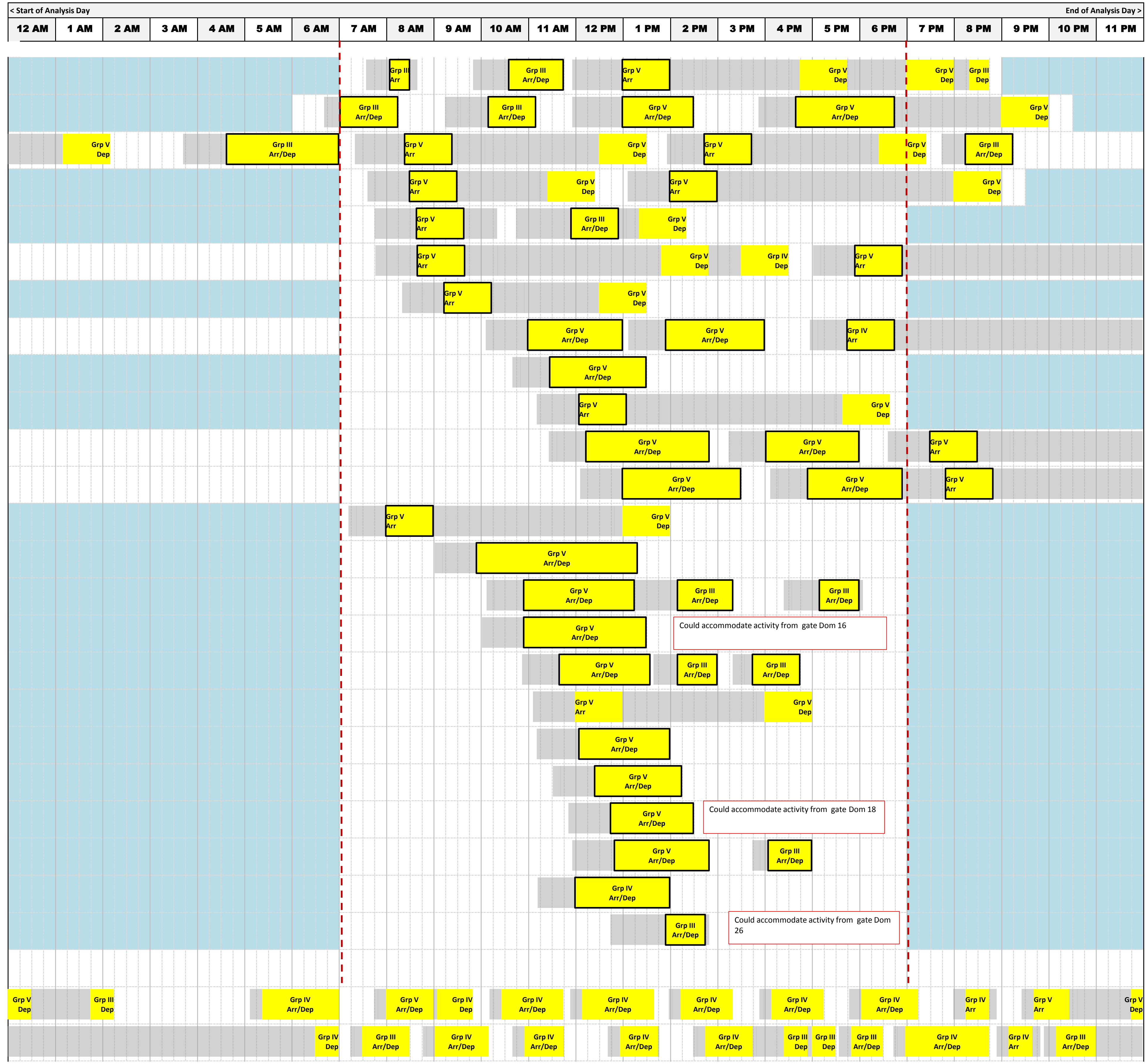


2024 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
OFF GATE 28	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 29	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 30	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 31	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 32	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 33	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 34	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 35	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 36	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 37	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 38	RON Offgate			E-190	CRJ-900		7	3.5
OFF GATE 39	RON Offgate			E-190	CRJ-900		2	1
OFF GATE 40	RON FIS gate			E-190	CRJ-900		3	1.5
OFF GATE 41	RON FIS gate			E-190	CRJ-900		1	0.5
OFF GATE 42	RON Offgate			E-190	CRJ-900		1	0.5
OFF GATE 43	RON Offgate			E-190	CRJ-900		2	1
OFF GATE 44	RON Offgate			B-777-300ER			6	3
OFF GATE 45	RON Offgate			B-777-300ER			4	2
OFF GATE 46	RON Offgate			B-767-300ERWL			2	1
OFF GATE 47	RON Offgate			B-767-300ERWL			4	2
OFF GATE 48	RON Offgate			B-767-300ERWL			2	1
OFF GATE 49	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 50	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 51	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 52	RON Offgate			E-190	CRJ-900		1	0.5



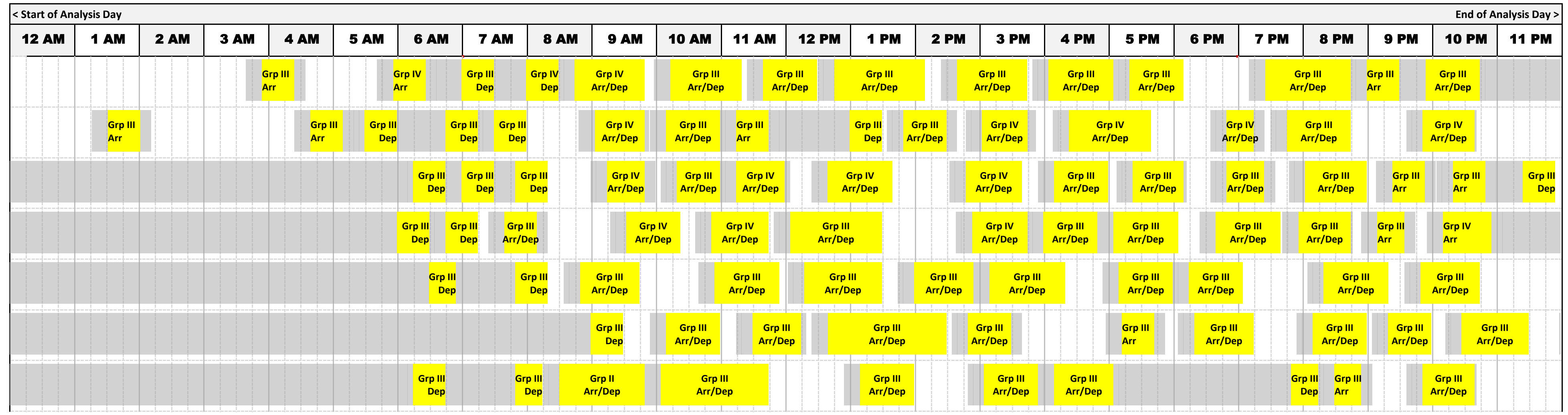
2029 Ramp Chart



Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
INT 1	Existing	V	1	B-777-300ER			7	3.5
INT 2	Existing	V	2	B-777-300ER			9	4.5
INT 3	Existing	V	3	B-777-300ER			9	4.5
INT 4	Existing	V	4	B-777-300ER			4	2
INT 5	Existing	V	5	B-777-300ER			4	2
INT 6	Existing	V	6	B-777-300ER			4	2
INT 7	Existing	V	7	B-777-300ER			2	1
INT 8	Existing	V	8	B-777-300ER			5	2.5
INT 9	Existing	V	9	B-777-300ER			2	1
INT 10	Existing	V	10	B-777-300ER			2	1
INT 11	New			B-777-300ER			5	2.5
INT 12	New			B-777-300ER			5	2.5
INT 13	New			B-777-300ER			2	1
INT 14	New			B-777-300ER			2	1
INT 15	New			B-777-300ER			6	3
INT 16	New			B-777-300ER			2	1
INT 17	New			B-777-300ER			6	3
INT 18	New			B-777-300ER			2	1
INT 19	New			B-777-300ER			2	1
INT 20	New			B-777-300ER			2	1
INT 21	New			B-777-300ER			2	1
INT 22	New			B-777-300ER			4	2
INT 23	Existing	IV	1	B-767-300ERWL			2	1
INT 24	Existing	IV	2	B-737-900WL	MD-80		2	1
DOM 1	Existing	V	1	B-777-300ER			20	10
DOM 2	Existing	IV	1	B-767-300ERWL			20	10

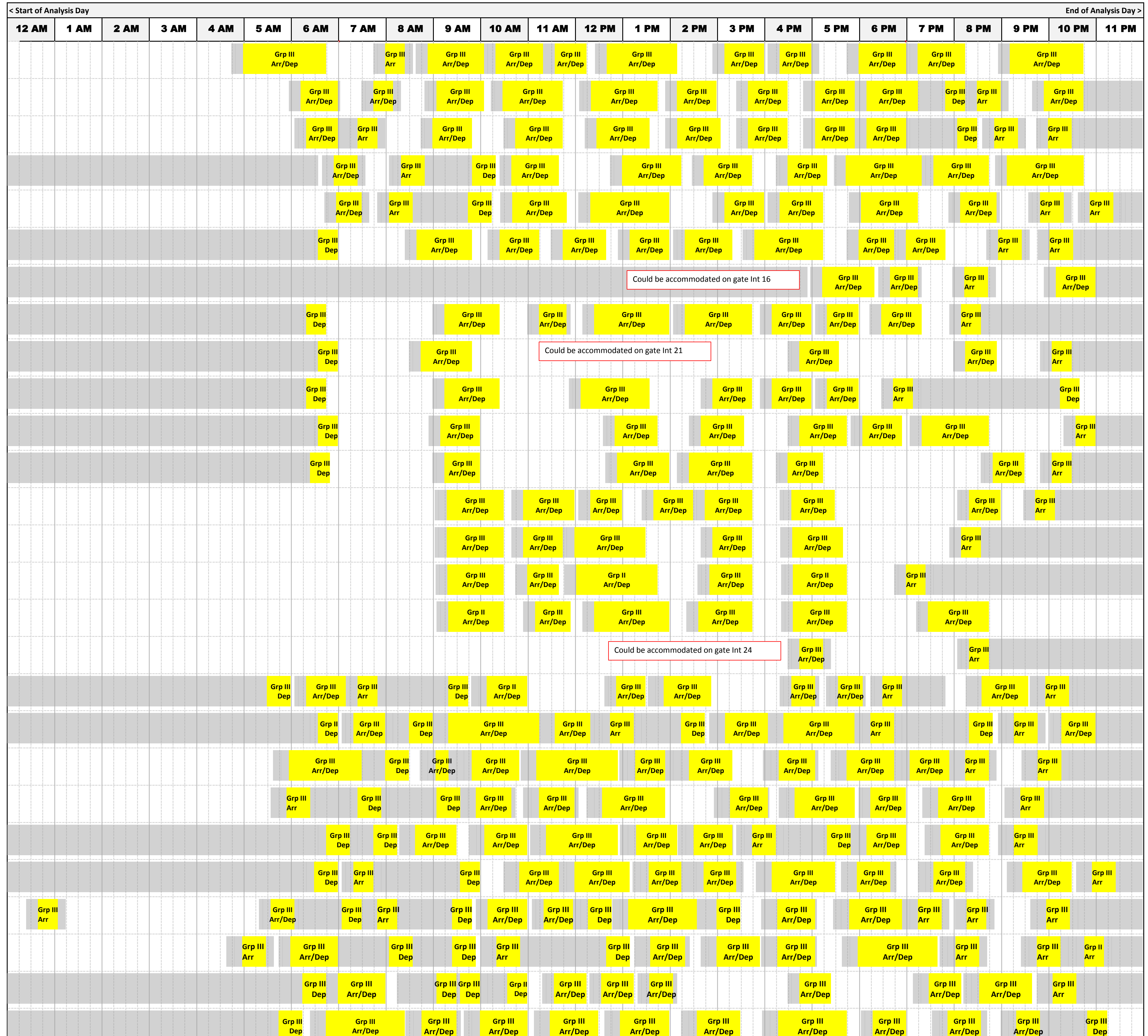
2029 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 3	Existing	IV	2	B-767-300ERWL			23	11.5
DOM 4	Existing	IV	3	B-767-300ERWL			23	11.5
DOM 5	Existing	IV	4	B-767-300ERWL			24	12
DOM 6	Existing	IV	5	B-767-300ERWL			22	11
DOM 7	Existing	III	1	B-737-900WL	MD-80		20	10
DOM 8	Existing	III	2	B-737-900WL	MD-80		18	9
DOM 9	Existing	III	3	B-737-900WL	MD-80		16	8



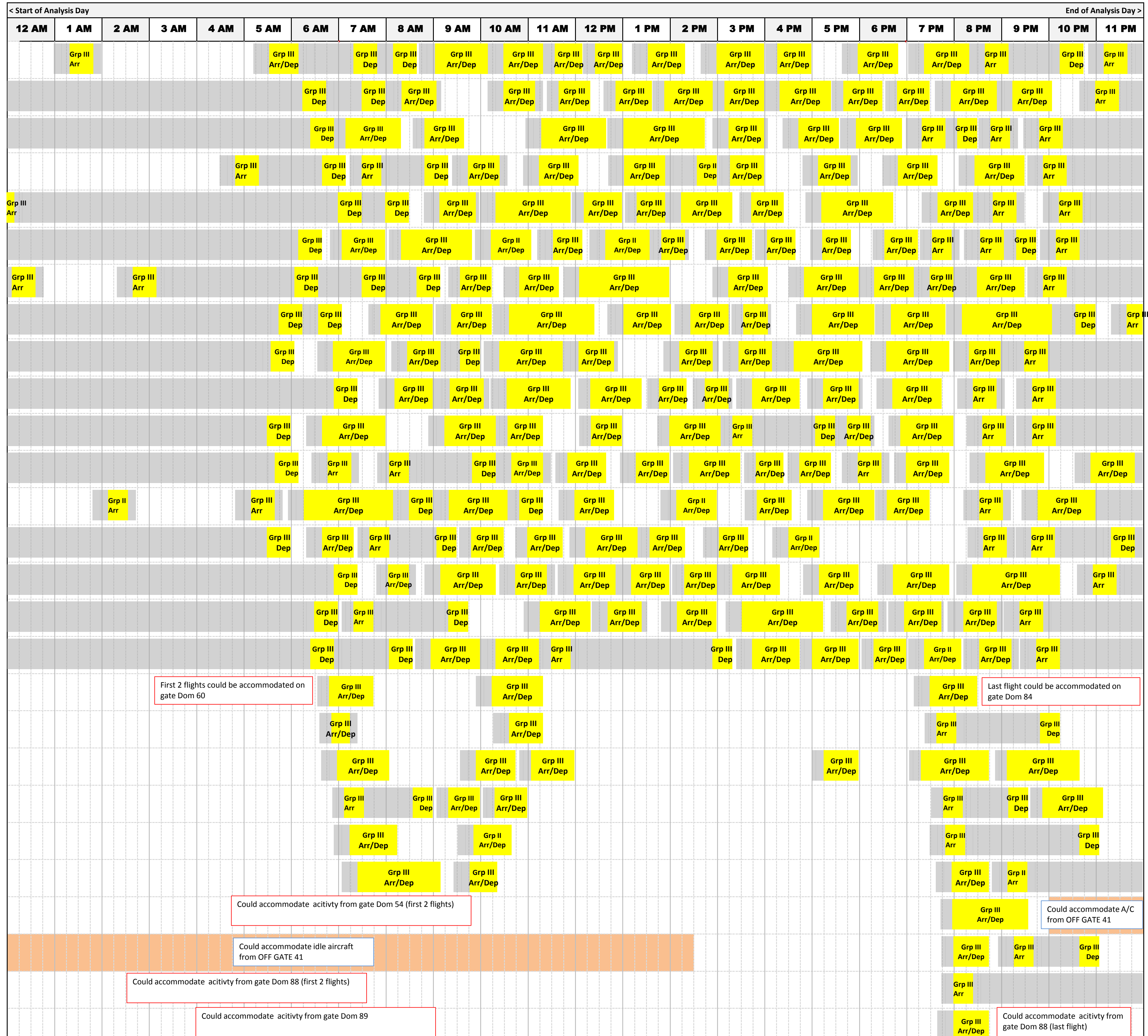
2029 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 10	Existing	III	4	B-737-900WL	MD-80		21	10.5
DOM 11	Existing	III	5	B-737-900WL	MD-80		22	11
DOM 12	Existing	III	6	B-737-900WL	MD-80		20	10
DOM 13	Existing	III	7	B-737-900WL	MD-80		18	9
DOM 14	Existing	III	8	B-737-900WL	MD-80		18	9
DOM 15	Existing	III	9	B-737-900WL	MD-80		19	9.5
DOM 16	Not Needed			B-737-900WL	MD-80		7	3.5
DOM 17	Existing	RJ	1	E-190	CRJ-900		16	8
DOM 18	Not Needed			E-190	CRJ-900		8	4
DOM 19	Existing	RJ	2	E-190	CRJ-900		13	6.5
DOM 20	Existing	RJ	3	E-190	CRJ-900		14	7
DOM 21	Existing	RJ	4	E-190	CRJ-900		12	6
DOM 22	Existing	RJ	5	E-190	CRJ-900		15	7.5
DOM 23	Existing	RJ	6	E-190	CRJ-900		11	5.5
DOM 24	Existing	RJ	7	E-190	CRJ-900		11	5.5
DOM 25	Existing	RJ	8	E-190	CRJ-900		12	6
DOM 26	Not Needed			E-190	CRJ-900		3	1.5
DOM 27	Existing	III	10	B-737-900WL	MD-80		19	9.5
DOM 28	Existing	III	11	B-737-900WL	MD-80		19	9.5
DOM 29	Existing	III	12	B-737-900WL	MD-80		21	10.5
DOM 30	Existing	III	13	B-737-900WL	MD-80		18	9
DOM 31	Existing	III	14	B-737-900WL	MD-80		19	9.5
DOM 32	Existing	III	15	B-737-900WL	MD-80		20	10
DOM 33	Existing	III	16	B-737-900WL	MD-80		21	10.5
DOM 34	Existing	III	17	B-737-900WL	MD-80		18	9
DOM 35	Existing	III	18	B-737-900WL	MD-80		19	9.5
DOM 36	Existing	III	19	B-737-900WL	MD-80		22	11



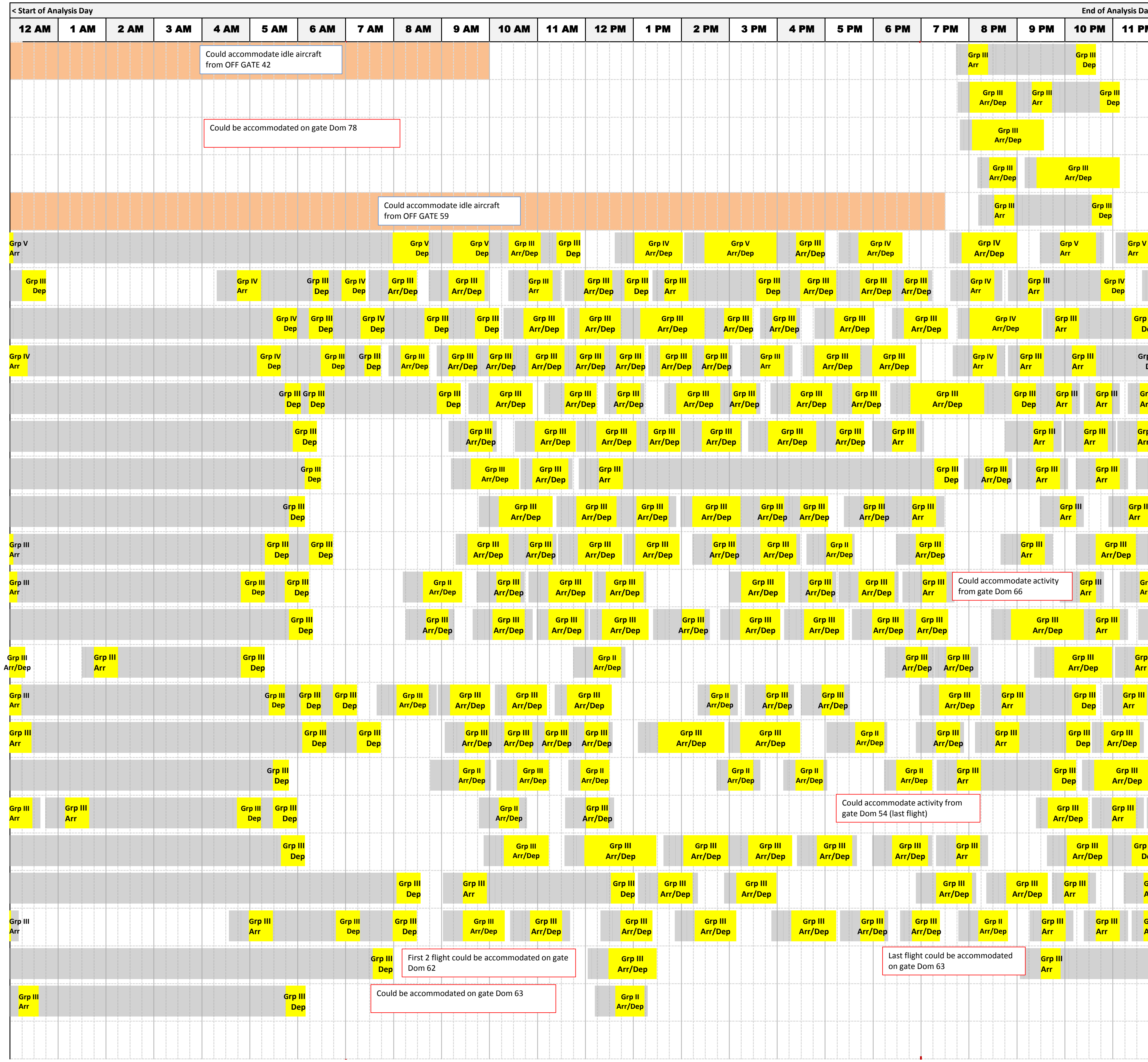
2029 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 37	Existing	III	20	B-737-900WL	MD-80		26	13
DOM 38	Existing	III	21	B-737-900WL	MD-80		25	12.5
DOM 39	Existing	III	22	B-737-900WL	MD-80		19	9.5
DOM 40	Existing	III	23	B-737-900WL	MD-80		20	10
DOM 41	Existing	III	24	B-737-900WL	MD-80		21	10.5
DOM 42	Existing	III	25	B-737-900WL	MD-80		25	12.5
DOM 43	Existing	III	26	B-737-900WL	MD-80		22	11
DOM 44	Existing	III	27	B-737-900WL	MD-80		22	11
DOM 45	Existing	III	28	B-737-900WL	MD-80		21	10.5
DOM 46	Existing	III	29	B-737-900WL	MD-80		21	10.5
DOM 47	Existing	III	30	B-737-900WL	MD-80		19	9.5
DOM 48	Existing	III	31	B-737-900WL	MD-80		23	11.5
DOM 49	Existing	III	32	B-737-900WL	MD-80		21	10.5
DOM 50	Existing	III	33	B-737-900WL	MD-80		20	10
DOM 51	Existing	III	34	B-737-900WL	MD-80		22	11
DOM 52	Existing	III	35	B-737-900WL	MD-80		18	9
DOM 53	Existing	III	36	B-737-900WL	MD-80		19	9.5
DOM 54	Not Needed			E-190	CRJ-900		6	3
DOM 55	Existing	RJ	9	E-190	CRJ-900		6	3
DOM 56	Existing	RJ	10	E-190	CRJ-900		12	6
DOM 57	Existing	RJ	11	E-190	CRJ-900		10	5
DOM 58	Existing	RJ	12	E-190	CRJ-900		6	3
DOM 59	Existing	RJ	13	E-190	CRJ-900		7	3.5
DOM 60	Existing	RJ	14	E-190	CRJ-900		2	1
DOM 61	Existing	RJ	15	E-190	CRJ-900		4	2
DOM 62	Existing	RJ	16	E-190	CRJ-900		1	0.5
DOM 63	Existing	RJ	17	E-190	CRJ-900		2	1

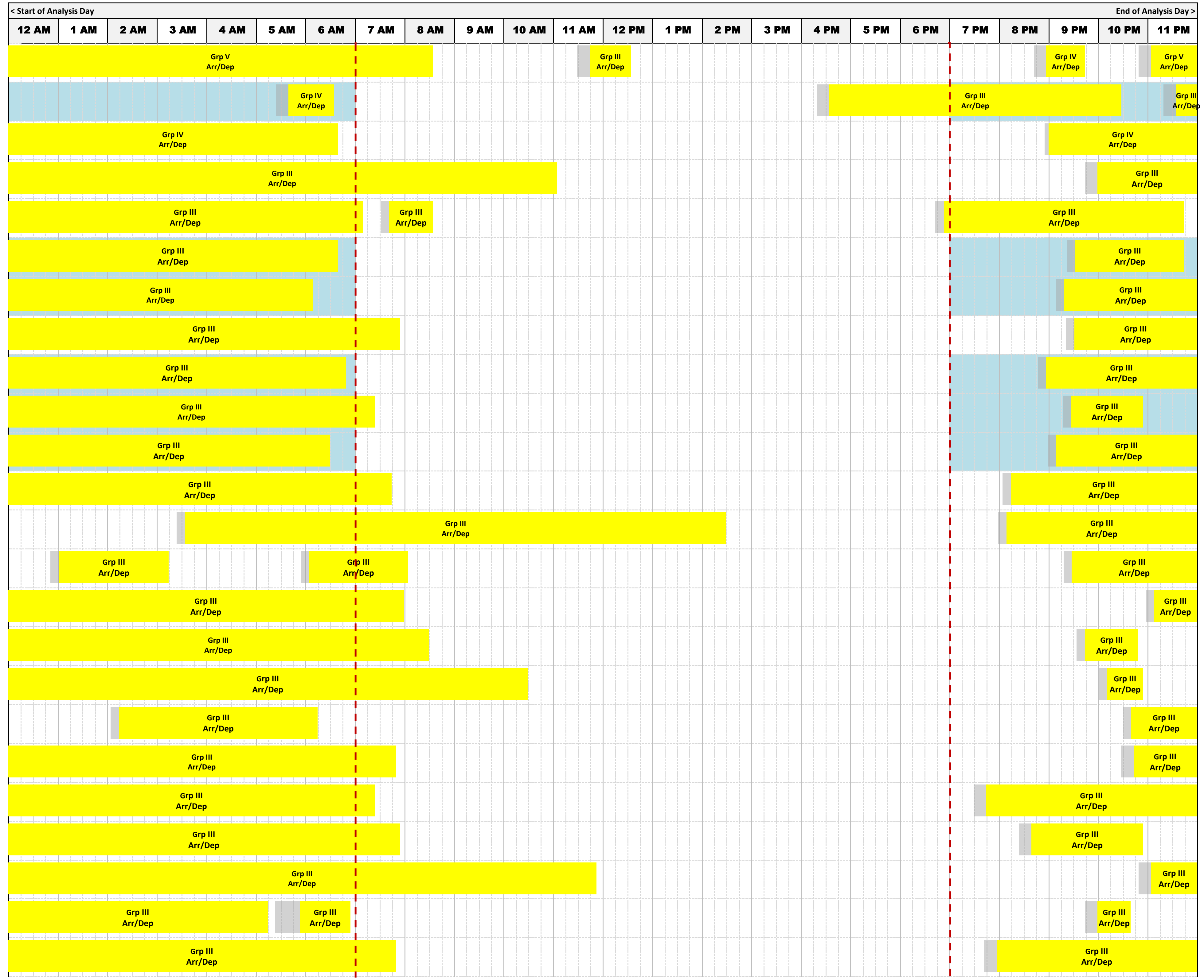


2029 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 64	Existing	RJ	18	E-190	CRJ-900		2	1
DOM 65	Existing	RJ	19	E-190	CRJ-900		4	2
DOM 66	Not Needed			E-190	CRJ-900		2	1
DOM 67	Existing	RJ	20	E-190	CRJ-900		4	2
DOM 68	New			E-190	CRJ-900		2	1
DOM 69	Existing	V	2	B-777-300ER			18	9
DOM 70	Existing	IV	6	B-767-300ERWL			24	12
DOM 71	Existing	IV	7	B-767-300ERWL			23	11.5
DOM 72	Existing	IV	8	B-767-300ERWL			29	14.5
DOM 73	Existing	III	37	B-737-900WL	MD-80		23	11.5
DOM 74	Existing	III	38	B-737-900WL	MD-80		19	9.5
DOM 75	Existing	III	39	B-737-900WL	MD-80		12	6
DOM 76	Existing	III	40	B-737-900WL	MD-80		18	9
DOM 77	New			B-737-900WL	MD-80		22	11
DOM 78	New			B-737-900WL	MD-80		20	10
DOM 79	New			B-737-900WL	MD-80		23	11.5
DOM 80	New			B-737-900WL	MD-80		13	6.5
DOM 81	New			B-737-900WL	MD-80		23	11.5
DOM 82	New			B-737-900WL	MD-80		23	11.5
DOM 83	New			B-737-900WL	MD-80		17	8.5
DOM 84	New			B-737-900WL	MD-80		12	6
DOM 85	New			B-737-900WL	MD-80		17	8.5
DOM 86	New			B-737-900WL	MD-80		13	6.5
DOM 87	New			B-737-900WL	MD-80		23	11.5
DOM 88	Not Needed			E-190	CRJ-900		4	2
DOM 89	Not Needed			E-190	CRJ-900		4	2



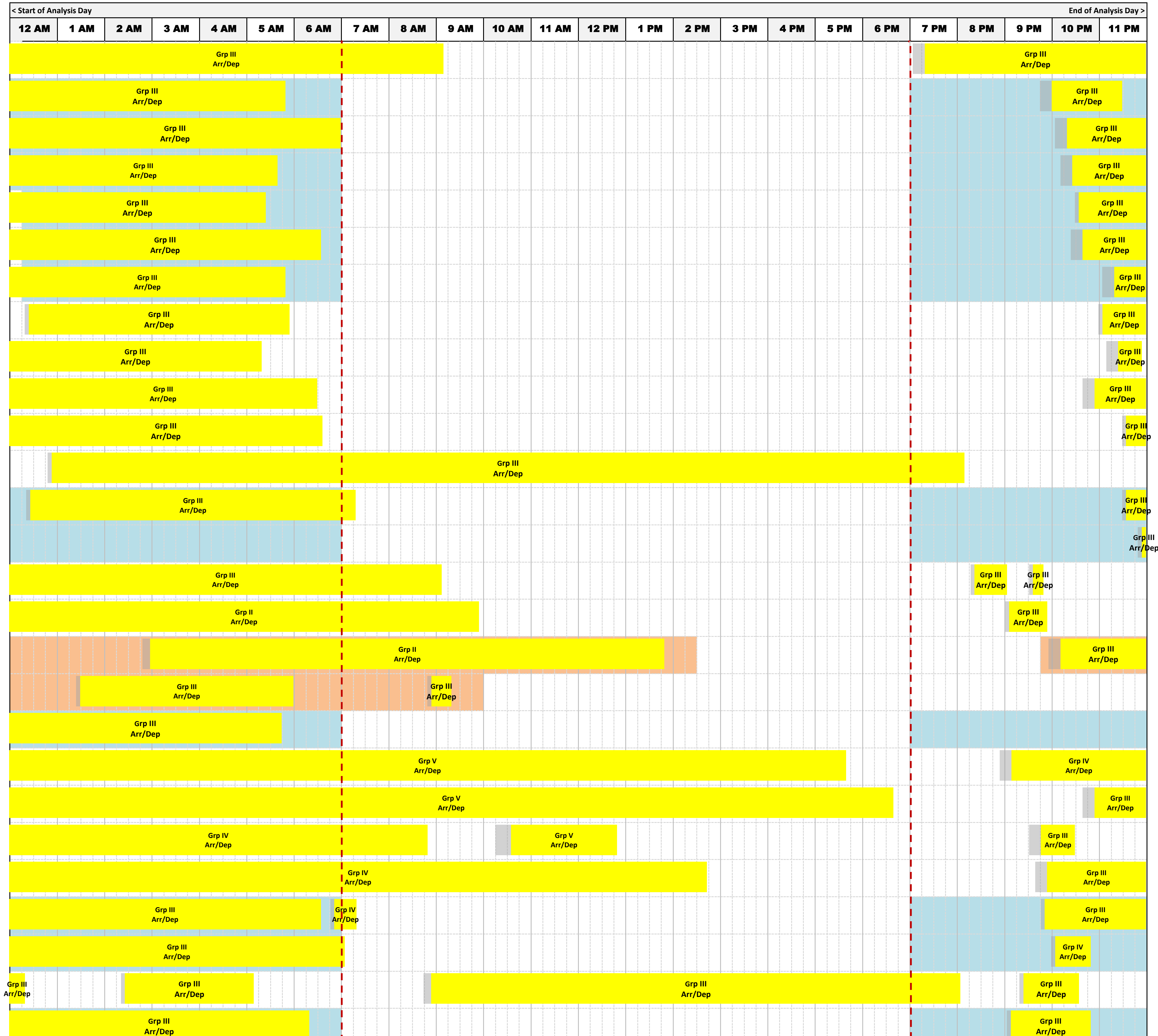
2029 Ramp Chart



Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
OFF GATE 1	RON Offgate			B-777-300ER			6	3
OFF GATE 2	RON FIS gate			B-767-300ERWL			5	2.5
OFF GATE 3	RON Offgate			B-767-300ERWL			3	1.5
OFF GATE 4	RON Offgate			B-767-300ERWL			2	1
OFF GATE 5	RON Offgate			B-737-900WL	MD-80		5	2.5
OFF GATE 6	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 7	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 8	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 9	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 10	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 11	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 12	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 13	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 14	RON Offgate			B-737-900WL	MD-80		5	2.5
OFF GATE 15	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 16	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 17	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 18	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 19	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 20	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 21	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 22	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 23	RON Offgate			B-737-900WL	MD-80		6	3
OFF GATE 24	RON Offgate			B-737-900WL	MD-80		2	1

2029 Ramp Chart

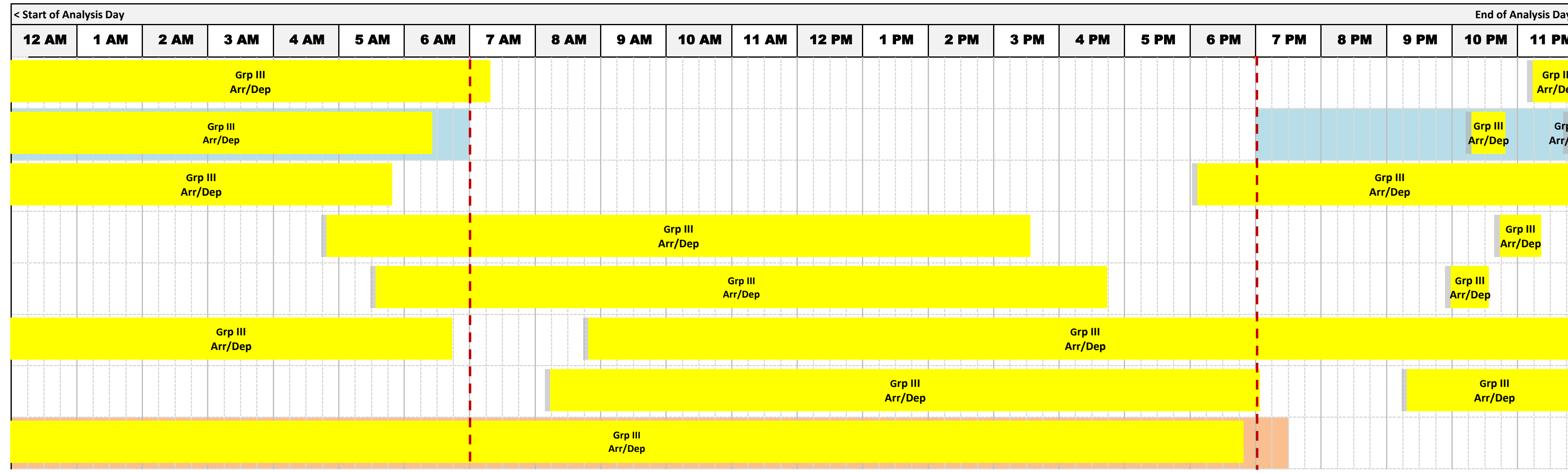
Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group
OFF GATE 25	RON Offgate			B-737-900WL	MD-80	
OFF GATE 26	RON FIS gate			B-737-900WL	MD-80	
OFF GATE 27	RON FIS gate			B-737-900WL	MD-80	
OFF GATE 28	RON FIS gate			B-737-900WL	MD-80	
OFF GATE 29	RON Offgate			B-737-900WL	MD-80	
OFF GATE 30	RON Offgate			B-737-900WL	MD-80	
OFF GATE 31	RON Offgate			B-737-900WL	MD-80	
OFF GATE 32	RON Offgate			B-737-900WL	MD-80	
OFF GATE 33	RON Offgate			B-737-900WL	MD-80	
OFF GATE 34	RON Offgate			B-737-900WL	MD-80	
OFF GATE 35	RON Offgate			B-737-900WL	MD-80	
OFF GATE 36	RON Offgate			B-737-900WL	MD-80	
OFF GATE 37	RON Offgate			B-737-900WL	MD-80	
OFF GATE 38	RON Offgate			B-737-900WL	MD-80	
OFF GATE 39	RON Offgate			E-190	CRJ-900	
OFF GATE 40	RON Offgate			E-190	CRJ-900	
OFF GATE 41	RON Offgate			E-190	CRJ-900	
OFF GATE 42	RON Offgate			E-190	CRJ-900	
OFF GATE 43	RON Offgate			E-190	CRJ-900	
OFF GATE 44	RON Offgate			B-777-300ER		
OFF GATE 45	RON Offgate			B-777-300ER		
OFF GATE 46	RON Offgate			B-777-300ER		
OFF GATE 47	RON Offgate			B-767-300ERWL		
OFF GATE 48	RON FIS gate			B-767-300ERWL		
OFF GATE 49	RON FIS gate			B-767-300ERWL		
OFF GATE 50	RON FIS gate			B-737-900WL	MD-80	
OFF GATE 51	RON FIS gate			B-737-900WL	MD-80	



Position	Arr + Dep	Turns
OFF GATE 25	2	1
OFF GATE 26	3	1.5
OFF GATE 27	2	1
OFF GATE 28	2	1
OFF GATE 29	2	1
OFF GATE 30	3	1.5
OFF GATE 31	2	1
OFF GATE 32	3	1.5
OFF GATE 33	3	1.5
OFF GATE 34	4	2
OFF GATE 35	3	1.5
OFF GATE 36	2	1
OFF GATE 37	3	1.5
OFF GATE 38	1	0.5
OFF GATE 39	5	2.5
OFF GATE 40	3	1.5
OFF GATE 41	3	1.5
OFF GATE 42	4	2
OFF GATE 43	1	0.5
OFF GATE 44	3	1.5
OFF GATE 45	2	1
OFF GATE 46	5	2.5
OFF GATE 47	2	1
OFF GATE 48	4	2
OFF GATE 49	3	1.5
OFF GATE 50	7	3.5
OFF GATE 51	3	1.5

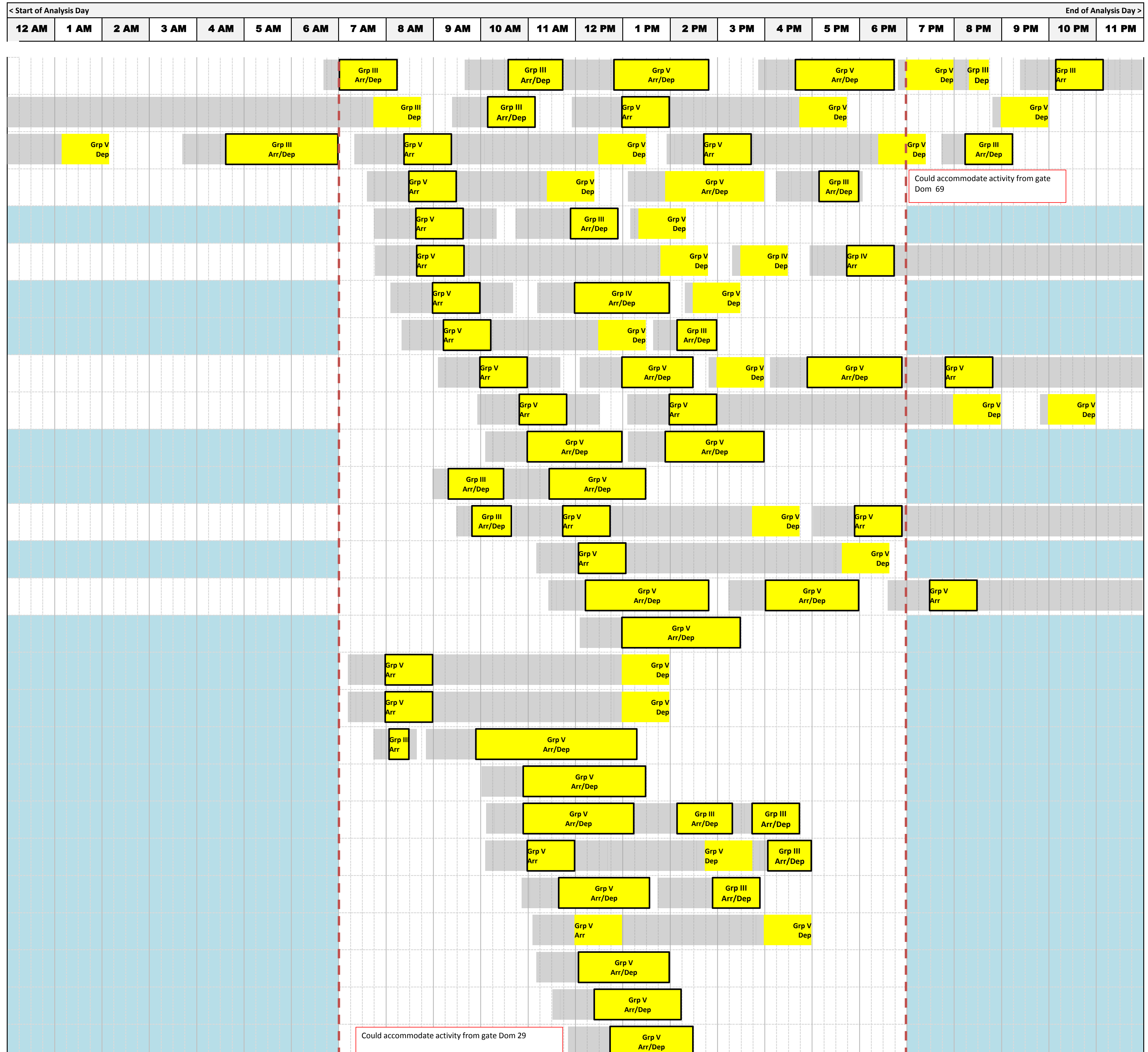
2029 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
OFF GATE 52	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 53	RON Offgate			B-737-900WL	MD-80		6	3
OFF GATE 54	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 55	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 56	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 57	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 58	RON Offgate			E-190	CRJ-900		3	1.5
OFF GATE 59	RON Offgate			E-190	CRJ-900		1	0.5



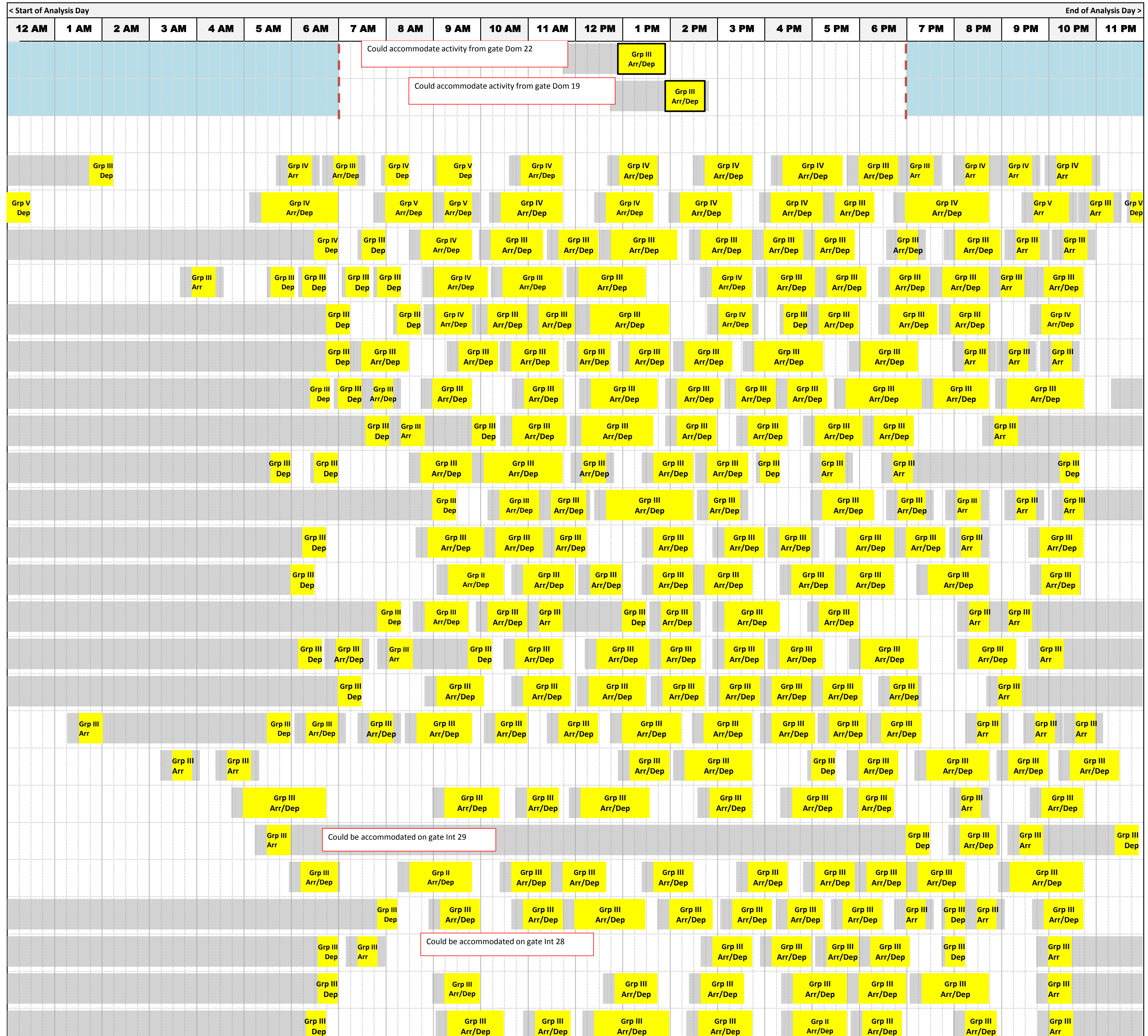
2034 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
INT 1	Existing	V	1	B-777-300ER			11	5.5
INT 2	Existing	V	2	B-777-300ER			6	3
INT 3	Existing	V	3	B-777-300ER			9	4.5
INT 4	Existing	V	4	B-777-300ER			6	3
INT 5	Existing	V	5	B-777-300ER			4	2
INT 6	Existing	V	6	B-777-300ER			4	2
INT 7	Existing	V	7	B-777-300ER			4	2
INT 8	Existing	V	8	B-777-300ER			4	2
INT 9	Existing	V	9	B-777-300ER			7	3.5
INT 10	Existing	V	10	B-777-300ER			4	2
INT 11	New			B-777-300ER			4	2
INT 12	New			B-777-300ER			4	2
INT 13	New			B-777-300ER			5	2.5
INT 14	New			B-777-300ER			2	1
INT 15	New			B-777-300ER			5	2.5
INT 16	New			B-777-300ER			2	1
INT 17	New			B-777-300ER			2	1
INT 18	New			B-777-300ER			2	1
INT 19	New			B-777-300ER			3	1.5
INT 20	New			B-777-300ER			2	1
INT 21	New			B-777-300ER			6	3
INT 22	New			B-777-300ER			4	2
INT 23	New			B-777-300ER			4	2
INT 24	New			B-777-300ER			2	1
INT 25	New			B-777-300ER			2	1
INT 26	New			B-777-300ER			2	1
INT 27	New			B-777-300ER			2	1



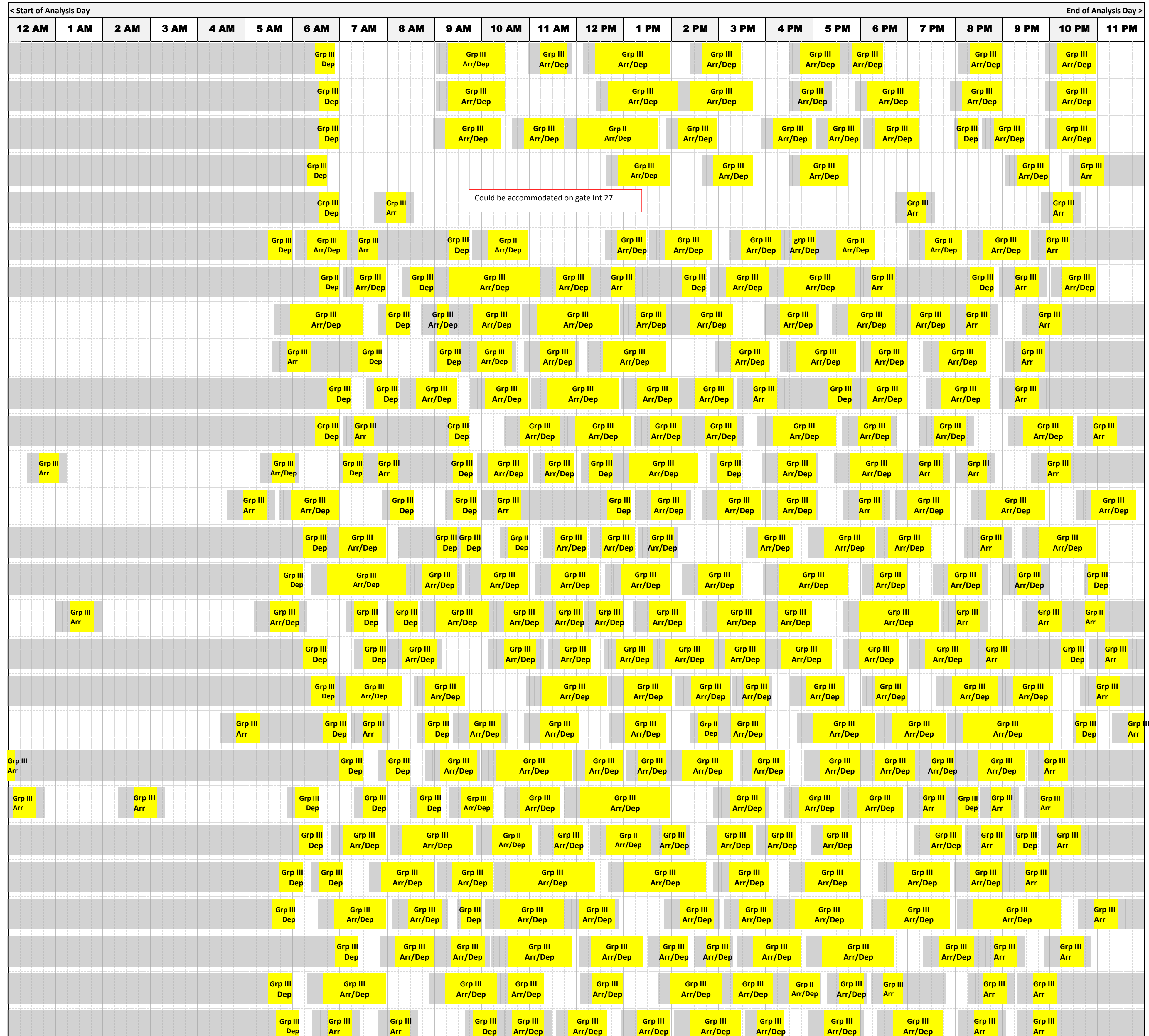
2034 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
INT 28	Existing	IV	1	B-737-900WL	MD-80		2	1
INT 29	Existing	IV	2	B-737-900WL	MD-80		2	1
DOM 1	Existing	V	1	B-777-300ER			20	10
DOM 2	Existing	V	2	B-777-300ER			22	11
DOM 3	Existing	IV	1	B-767-300ERWL			22	11
DOM 4	Existing	IV	2	B-767-300ERWL			24	12
DOM 5	Existing	IV	3	B-767-300ERWL			21	10.5
DOM 6	Existing	III	1	B-737-900WL	MD-80		20	10
DOM 7	Existing	III	2	B-737-900WL	MD-80		22	11
DOM 8	Existing	III	3	B-737-900WL	MD-80		16	8
DOM 9	Existing	III	4	B-737-900WL	MD-80		16	8
DOM 10	Existing	III	5	B-737-900WL	MD-80		16	8
DOM 11	Existing	III	6	B-737-900WL	MD-80		20	10
DOM 12	Existing	III	7	B-737-900WL	MD-80		19	9.5
DOM 13	Existing	III	8	B-737-900WL	MD-80		15	7.5
DOM 14	Existing	III	9	B-737-900WL	MD-80		20	10
DOM 15	Existing	III	10	B-737-900WL	MD-80		18	9
DOM 16	Existing	III	11	B-737-900WL	MD-80		25	12.5
DOM 17	Existing	III	12	B-737-900WL	MD-80		15	7.5
DOM 18	Existing	III	13	B-737-900WL	MD-80		17	8.5
DOM 19	Not Needed			B-737-900WL	MD-80		6	3
DOM 20	Existing	III	14	B-737-900WL	MD-80		20	10
DOM 21	Existing	III	15	B-737-900WL	MD-80		20	10
DOM 22	Not Needed			B-737-900WL	MD-80		12	6
DOM 23	Existing	III	16	B-737-900WL	MD-80		14	7
DOM 24	Existing	III	17	B-737-900WL	MD-80		16	8



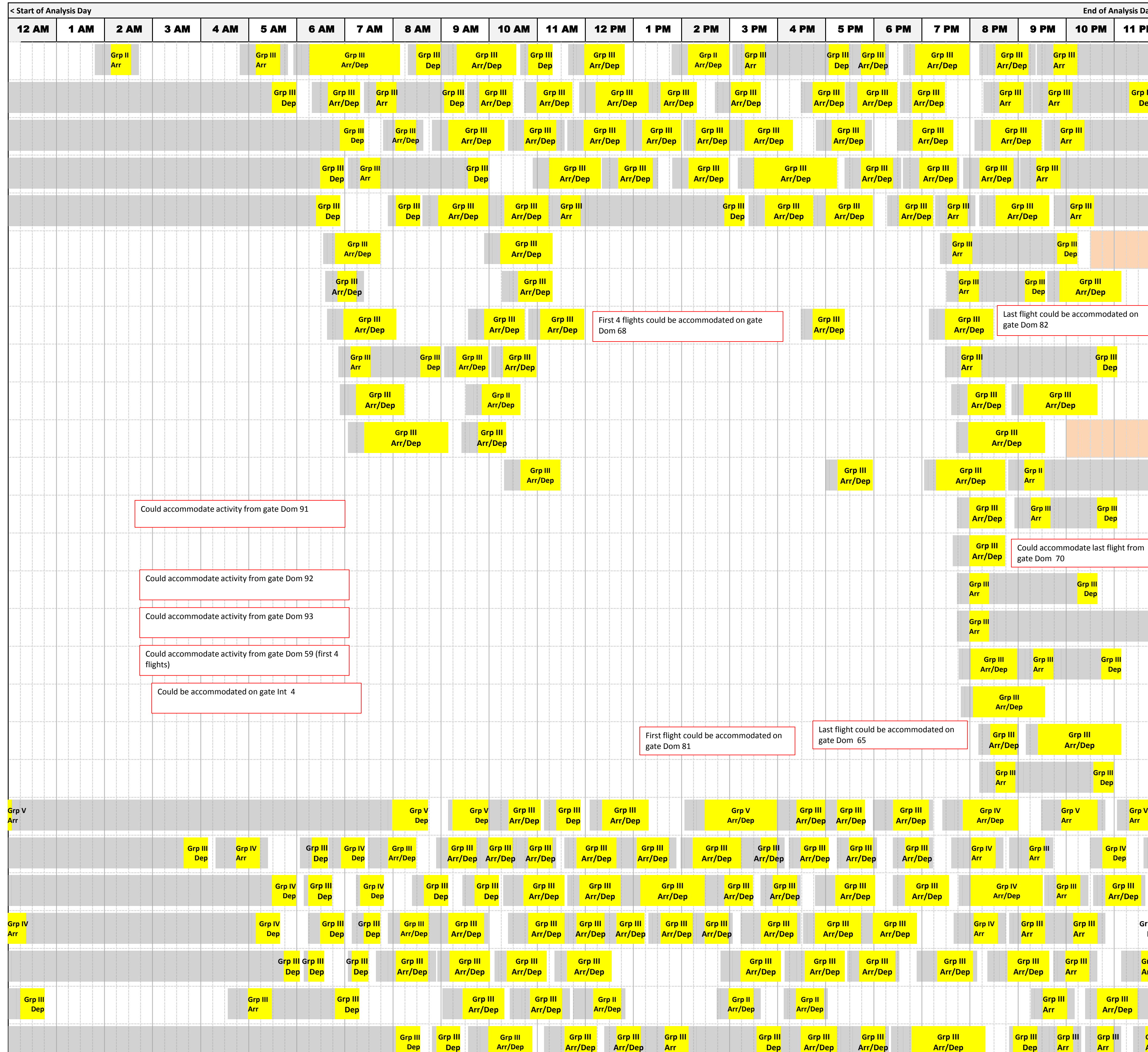
2034 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 25	Existing	III	18	B-737-900WL	MD-80		17	8.5
DOM 26	Existing	III	19	B-737-900WL	MD-80		15	7.5
DOM 27	Existing	III	20	B-737-900WL	MD-80		20	10
DOM 28	Existing	III	21	B-737-900WL	MD-80		10	5
DOM 29	Not Needed			B-737-900WL	MD-80		4	2
DOM 30	Existing	III	22	B-737-900WL	MD-80		22	11
DOM 31	Existing	III	23	B-737-900WL	MD-80		19	9.5
DOM 32	Existing	III	24	B-737-900WL	MD-80		21	10.5
DOM 33	Existing	III	25	B-737-900WL	MD-80		18	9
DOM 34	Existing	III	26	B-737-900WL	MD-80		19	9.5
DOM 35	Existing	III	27	B-737-900WL	MD-80		20	10
DOM 36	Existing	III	28	B-737-900WL	MD-80		21	10.5
DOM 37	Existing	III	29	B-737-900WL	MD-80		20	10
DOM 38	Existing	III	30	B-737-900WL	MD-80		21	10.5
DOM 39	Existing	III	31	B-737-900WL	MD-80		22	11
DOM 40	Existing	III	32	B-737-900WL	MD-80		24	12
DOM 41	Existing	III	33	B-737-900WL	MD-80		23	11.5
DOM 42	Existing	III	34	B-737-900WL	MD-80		22	11
DOM 43	Existing	III	35	B-737-900WL	MD-80		21	10.5
DOM 44	Existing	III	36	B-737-900WL	MD-80		24	12
DOM 45	Existing	III	37	B-737-900WL	MD-80		21	10.5
DOM 46	Existing	III	38	B-737-900WL	MD-80		24	12
DOM 47	Existing	III	39	B-737-900WL	MD-80		19	9.5
DOM 48	Existing	III	40	B-737-900WL	MD-80		21	10.5
DOM 49	New			B-737-900WL	MD-80		21	10.5
DOM 50	New			B-737-900WL	MD-80		20	10
DOM 51	New			B-737-900WL	MD-80		20	10



2034 Ramp Chart

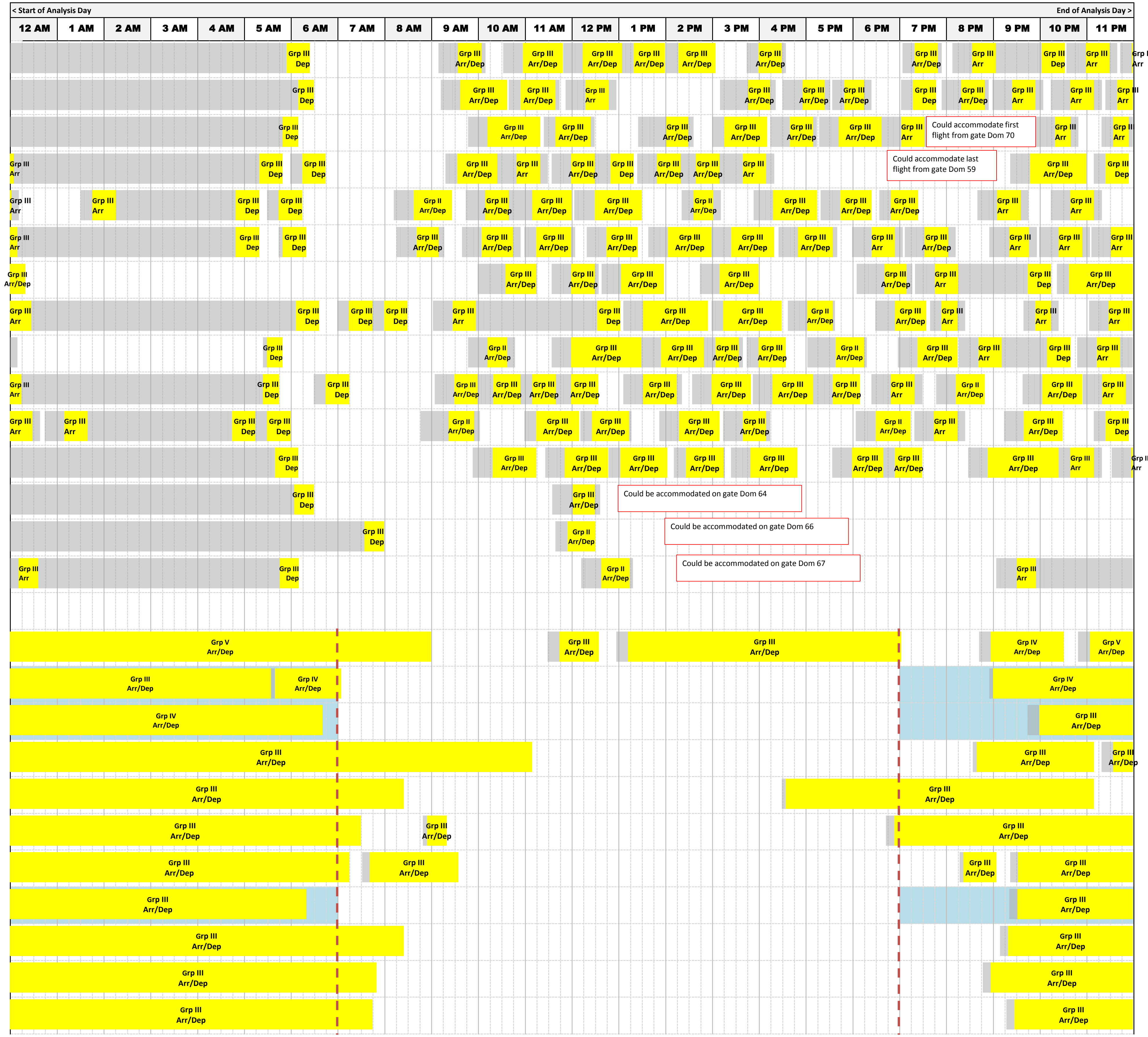
Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 52	Existing	III	41	B-737-900WL	MD-80		21	10.5
DOM 53	Existing	III	42	B-737-900WL	MD-80		24	12
DOM 54	Existing	III	43	B-737-900WL	MD-80		22	11
DOM 55	Existing	III	44	B-737-900WL	MD-80		18	9
DOM 56	Existing	III	45	B-737-900WL	MD-80		18	9
DOM 57	Existing	RJ	1	E-190	CRJ-900		6	3
DOM 58	Existing	RJ	2	E-190	CRJ-900		8	4
DOM 59	Not Needed			E-190	CRJ-900		10	5
DOM 60	Existing	RJ	3	E-190	CRJ-900		8	4
DOM 61	Existing	RJ	4	E-190	CRJ-900		8	4
DOM 62	Existing	RJ	5	E-190	CRJ-900		6	3
DOM 63	Existing	RJ	6	E-190	CRJ-900		7	3.5
DOM 64	Existing	RJ	7	E-190	CRJ-900		4	2
DOM 65	Existing	RJ	8	E-190	CRJ-900		2	1
DOM 66	Existing	RJ	9	E-190	CRJ-900		2	1
DOM 67	Existing	RJ	10	E-190	CRJ-900		1	0.5
DOM 68	Existing	RJ	11	E-190	CRJ-900		4	2
DOM 69	Not Needed			E-190	CRJ-900		2	1
DOM 70	Not Needed			E-190	CRJ-900		4	2
DOM 71	Existing	RJ	12	E-190	CRJ-900		2	1
DOM 72	Existing	V	3	B-777-300ER			20	10
DOM 73	Existing	IV	4	B-767-300ERWL			30	15
DOM 74	Existing	IV	5	B-767-300ERWL			24	12
DOM 75	Existing	IV	6	B-767-300ERWL			28	14
DOM 76	New			B-737-900WL	MD-80		23	11.5
DOM 77	New			B-737-900WL	MD-80		17	8.5
DOM 78	New			B-737-900WL	MD-80		20	10



2034 Ramp Chart

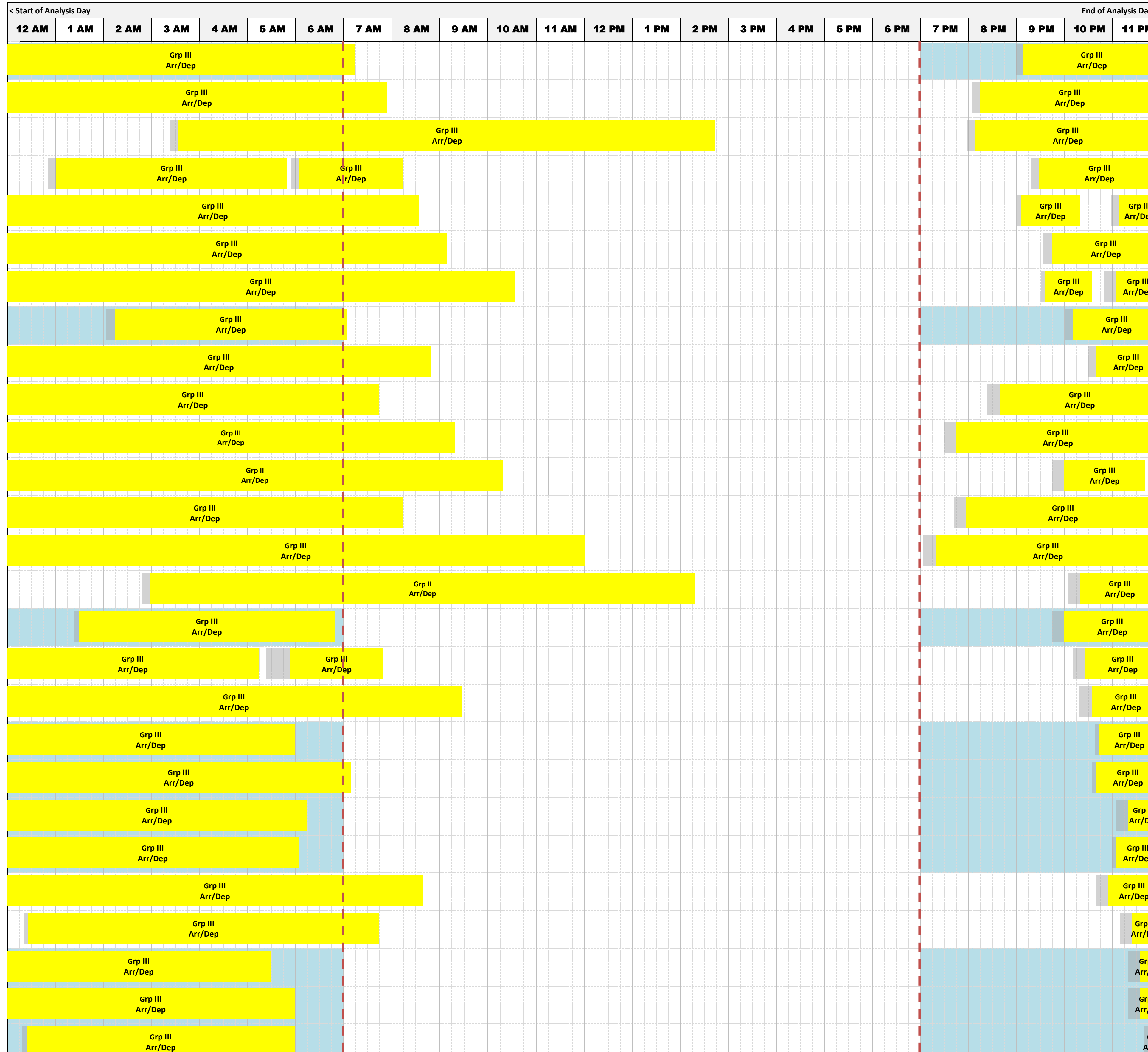
Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
DOM 79	New			B-737-900WL	MD-80		19	9.5
DOM 80	New			B-737-900WL	MD-80		18	9
DOM 81	New			B-737-900WL	MD-80		16	8
DOM 82	New			B-737-900WL	MD-80		17	8.5
DOM 83	New			B-737-900WL	MD-80		22	11
DOM 84	New			B-737-900WL	MD-80		23	11.5
DOM 85	New			B-737-900WL	MD-80		16	8
DOM 86	New			B-737-900WL	MD-80		17	8.5
DOM 87	New			B-737-900WL	MD-80		18	9
DOM 88	New			B-737-900WL	MD-80		25	12.5
DOM 89	New			B-737-900WL	MD-80		20	10
DOM 90	New			B-737-900WL	MD-80		19	9.5
DOM 91	Not Needed			E-190	CRJ-900		3	1.5
DOM 92	Not Needed			E-190	CRJ-900		3	1.5
DOM 93	Not Needed			E-190	CRJ-900		5	2.5

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
OFF GATE 1	RON Offgate			B-777-300ER			8	4
OFF GATE 2	RON FIS gate			B-767-300ERWL			4	2
OFF GATE 3	RON FIS gate			B-767-300ERWL			2	1
OFF GATE 4	RON Offgate			B-767-300ERWL			4	2
OFF GATE 5	RON Offgate			B-767-300ERWL			3	1.5
OFF GATE 6	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 7	RON Offgate			B-737-900WL	MD-80		6	3
OFF GATE 8	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 9	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 10	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 11	RON Offgate			B-737-900WL	MD-80		2	1



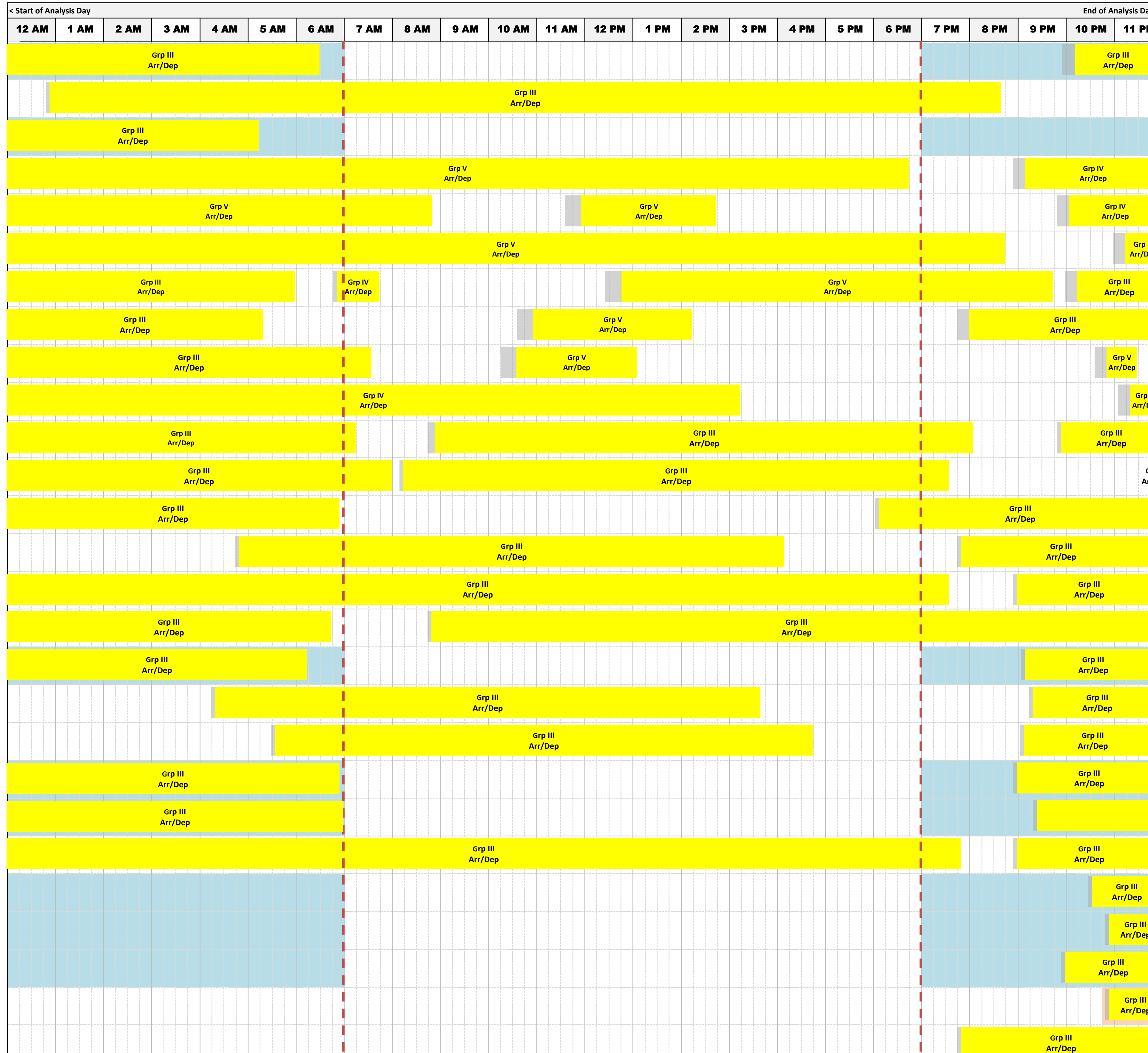
2034 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
OFF GATE 12	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 13	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 14	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 15	RON Offgate			B-737-900WL	MD-80		5	2.5
OFF GATE 16	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 17	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 18	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 19	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 20	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 21	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 22	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 23	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 24	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 25	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 26	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 27	RON FIS gate			B-737-900WL	MD-80		4	2
OFF GATE 28	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 29	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 30	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 31	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 32	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 33	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 34	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 35	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 36	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 37	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 38	RON FIS gate			B-737-900WL	MD-80		3	1.5



2034 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	Arr + Dep	Turns
OFF GATE 39	RON FIS gate			B-737-900WL	MD-80		3	1.5
OFF GATE 40	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 41	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 42	RON Offgate			B-777-300ER			2	1
OFF GATE 43	RON Offgate			B-777-300ER			4	2
OFF GATE 44	RON Offgate			B-777-300ER			2	1
OFF GATE 45	RON Offgate			B-777-300ER			6	3
OFF GATE 46	RON Offgate			B-777-300ER			4	2
OFF GATE 47	RON Offgate			B-777-300ER			5	2.5
OFF GATE 48	RON Offgate			B-767-300ERWL			2	1
OFF GATE 49	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 50	RON Offgate			B-737-900WL	MD-80		4	2
OFF GATE 51	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 52	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 53	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 54	RON Offgate			B-737-900WL	MD-80		2	1
OFF GATE 55	RON FIS gate			B-737-900WL	MD-80		2	1
OFF GATE 56	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 57	RON Offgate			B-737-900WL	MD-80		3	1.5
OFF GATE 58	RON FIS gate			B-737-900WL	MD-80		1	0.5
OFF GATE 59	RON Offgate			B-737-900WL	MD-80		1	0.5
OFF GATE 60	RON Offgate			E-190	CRJ-900		2	1
OFF GATE 61	RON FIS gate			E-190	CRJ-900		1	0.5
OFF GATE 62	RON FIS gate			E-190	CRJ-900		1	0.5
OFF GATE 63	RON FIS gate			E-190	CRJ-900		1	0.5
OFF GATE 64	RON Offgate			E-190	CRJ-900		1	0.5
OFF GATE 65	RON Offgate			E-190	CRJ-900		1	0.5



2034 Ramp Chart

Position	Based on 'Mix B' assuming the largest aircraft size mix	Jet Type	Jet Type Count	Max Wingspan Acrft	Max Length Acrft	Depend Group	< Start of Analysis Day 12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM End of Analysis Day >	Arr + Dep	Turns
OFF GATE 66	RON Offgate			E-190	CRJ-900																								Grp III Arr/Dep		1	0.5