Chapter 3. Facility Requirements

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Chapter 3 Facility Requirements

This chapter describes the airfield, terminal, and landside facility requirements needed to accommodate the current and forecast demand at the Minneapolis-Saint. Paul International Airport (MSP) through the 2040 planning period. The landside section discusses the requirements for elements such as terminal area access and egress, curbside facilities, parking, rental car facilities, and the Ground Transportation Center (GTC). The terminal section highlights facility requirements through a gap analysis, comparing existing terminal facilities to future requirements. The airfield section reviews all requirements related to elements such as runways, taxiways, and airfield capacity.

3.1 LANDSIDE

This section documents the requirements for future terminal curbside facilities, parking, rental car facilities, and GTC. The future facility requirements were determined using a data-driven approach, incorporating historical MSP landside activity and forecast aviation activity. Landside requirements were determined using actual traffic and parking data collected in 2019. They are not based on the 2018 Design Day Flight Schedule (DDFS). Technical memoranda detailing the methodology and results for the landside requirements are included in **Appendix C.1**.

3.1.1 Roadway Access and Curbfront Requirements

3.1.1.1 Terminal Curbfront Access Roadways

The access roadway requirements were determined through methodologies defined in the Airport Cooperative Research Program (ACRP) Report 40, *Airport Curbside and Terminal Area Roadway Operations*. Roadway capacity for a given roadway segment considers the number of lanes and free-flow speed. The resulting Level-of-Service (LOS) is a function of the volume-to-capacity ratio and free-flow speed. LOS C is the target LOS threshold for planning new airport facilities; however, at large-hub airports, LOS D may be considered acceptable on existing roadways during peak periods to serve the forecast vehicular demand. **Table 3-1** presents the LOS provided by the access and egress lanes to the curbside facilities at each terminal. In response to feedback from stakeholders, this analysis assumed two lanes are provided to Terminal 1 (T1) departures and arrivals facilities.

Table 3-1: Curbside Access and Egress Roadway Performance (LOS)[1]

	T1 Departures (2 Lanes)	T1 Arrivals (2 Lanes)	T2 Arrivals/Departures (3 Lanes)
Base (2019)	D	C	B
PAL 1	D	C	B
PAL 3 (Spring)	E	C	C

NOTES:
PAL – Planning Activity Level
1 Curbside requirements for PAL 2 are intentionally not presented. It is best practice to design curbside facilities to meet requirements at the end of the planning horizon.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

3.1.1.2 Terminal Curbfront Roadways

The Advanced Land Transportation Performance Simulation (ALPS™) microsimulation model was used to better understand the future demand on the airport's terminal curbfront roadways. Like the access roadways, a target LOS C was used for the departures and arrivals curbside requirements, as recommended by ACRP Report 40. The data inputs, data processing, and planning assumptions that were made when developing the ALPS™ model are provided in the technical memorandum in **Appendix C.1**. The modeling assumed only private vehicles are permitted to pick up passengers at the arrivals curbfront. The modeling also assumed private vehicles, taxis, and Transportation Network Companies (TNCs) are permitted to drop off passengers at the departures curbfront.

Traffic volumes derived from the ALPS™ model were used as inputs for the ACRP Quick Analysis Tool for Airport Roadways (QATAR), a planning-level macroscopic analysis tool for estimating airport terminal curbfront LOS. This helped determine the departures and arrivals curbside requirements. The QATAR analysis assumed double-lane curbing is allowed at both terminals. The QATAR analysis also assumed a four-lane roadway cross section existed, which provides two lanes for through traffic. The T1 and Terminal 2 (T2) baseline departures and arrivals curbside requirements are presented in **Table 3-2**, **Table 3-3**, **Table 3-4**, and **Table 3-5**, respectively. Additional curbside requirements analysis results are provided in **Appendix C.1**.

Table 3-2: T1 Departures Curbside Requirements (Double-Lane Curbing / LOS C)[1]

	Peak Hour	Peak-Hour Curbing Volumes	Departures Curb (Departures Peak)	Surplus/(Deficit)
Base (2019)	4:45 A.M.	1,087'	840'	(10')
PAL 1	4:45 A.M.	1,069'	840'	(10')
PAL 3 (Summer)	6:45 A.M.	1,400'	1,130'	(300')

NOTES:
PAL – Planning Activity Level
1 Curbside requirements for PAL 2 are intentionally not presented. It is best practice to design curbside facilities to meet requirements at the end of the planning horizon.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

Table 3-3: T1 Arrivals Curbside Requirements (Double-Lane Curbing / LOS C)[1,2]

	Peak Hour	Peak-Hour Curbing Volumes	Arrivals Curb (Arrivals Peak)	Surplus/(Deficit)
Base (2019)	6:30 P.M.	604'	840'	(140')
PAL 1	4:45 P.M.	581'	815'	(115')
PAL 3 (Summer)	4:30 P.M.	1,180'	1,130'	(430')

NOTES:
PAL – Planning Activity Level
1 Vehicular recirculation for the arrivals curbfront at T1 was assumed to be 20%.
2 Curbside requirements for PAL 2 are intentionally not presented. It is best practice to design curbside facilities to meet requirements at the end of the planning horizon.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

Table 3-4: T2 Departures Curbside Requirements (Double-Lane Curbing / LOS C)[1]

	Peak Hour	Peak-Hour Curbing Volumes	Departures Curb (Departures Peak)	Surplus/(Deficit)
Base (2019)	4:45 A.M.	530’	490’	210’
PAL 1	4:30 A.M.	482’	440’	260’
PAL 3 (Spring)	4:30 A.M.	821’	690’	10’

NOTES:
PAL – Planning Activity Level
1 Curbside requirements for PAL 2 are intentionally not presented. It is best practice to design curbside facilities to meet requirements at the end of the planning horizon.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

Table 3-5: T2 Arrivals Curbside Requirements (Double-Lane Curbing / LOS C)[1,2]

	Peak Hour	Peak-Hour Curbing Volumes	Arrivals Curb (Arrivals Peak)	Surplus/(Deficit)
Base (2019)	1:45 P.M.	273’	590’	(140’)
PAL 1	1:30 P.M.	392’	715’	(265’)
PAL 3 (Spring)	2:00 P.M.	757’	940’	(490’)

NOTES:
PAL – Planning Activity Level
1 Vehicular recirculation for the arrivals curbfront at T2 was assumed to be 40% (20% recirculate directly to the curbfront, and 20% recirculate to the cell phone lot).
2 Curbside requirements for PAL 2 are intentionally not presented. It is best practice to design curbside facilities to meet requirements at the end of the planning horizon.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

3.1.2 Parking Requirements

Airport public parking facilities accommodate both public parkers and a subset of employee parkers. Additional public parking supply is currently provided by off-airport private facilities. A baseline parking requirements analysis was performed, which assumed no change in passenger and employee behavior over the planning period. Changes in customer behavior over time could result in changing parking requirements at a given PAL. Potential changes to customer behavior and the resulting impacts to landside requirements were evaluated through PAL 1, as documented in **Appendix C.3**.

Exhibit 3-1 illustrates the general methodology used to determine the employee and public parking requirements.

Exhibit 3-1: Parking Requirements Methodology

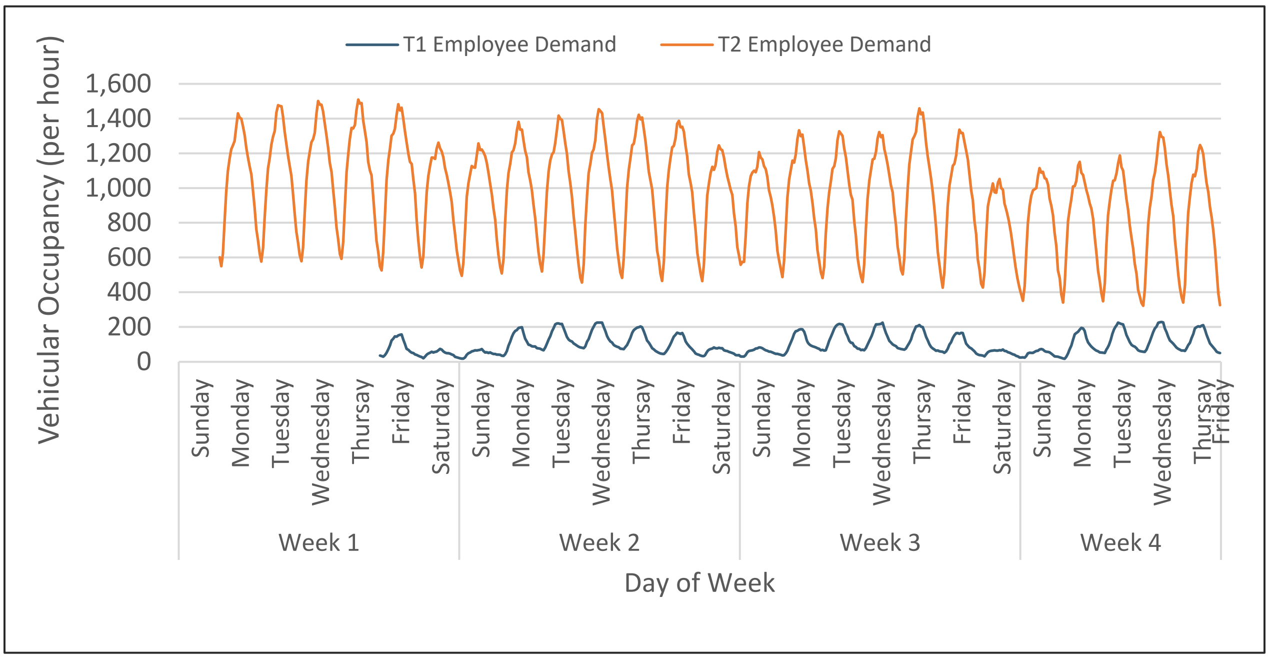
SOURCE: Kimley-Horn and Associates, Inc., 2022.

3.1.2.1 Employee Parking

Employee parking requirements were calculated for a subset of airline, tenant, and concessionaire employees. The analysis only included employees parking in public parking facilities managed by the Metropolitan Airports Commission (MAC) Parking Access and Revenue Control System (PARCS). An analysis estimating the amount of Delta employees parking outside MAC facilities is included for planning purposes, which is related to alternatives impacting existing Delta employee parking.

The employee parking requirements were based on parking transaction data from the airport's PARCS. Employee entry and exit transaction data were used to determine employee parking demand because discreet employee parking occupancy data were not available. **Exhibit 3-2** shows the peak occupancy at both T1 and T2, which was selected to determine the employee parking demand. To determine the existing employee parking stall requirement, a 10% service factor was applied to the demand to account for known inefficiencies in parking operations and peaking characteristics during shift changes.

Exhibit 3-2: Employee Parking Occupancy (March 2019)



NOTES:
T1 – Terminal 1; T2 – Terminal 2
SOURCE: Kimley-Horn and Associates, Inc., 2022.

The existing employee parking stall requirement grew at the same rate as annual passenger aircraft operations to determine future requirements, with requirements assumed to be consistent throughout the year. **Table 3-6** presents the resulting employee parking requirements.

Table 3-6: Existing and Future Employee Parking Requirements (Stalls)

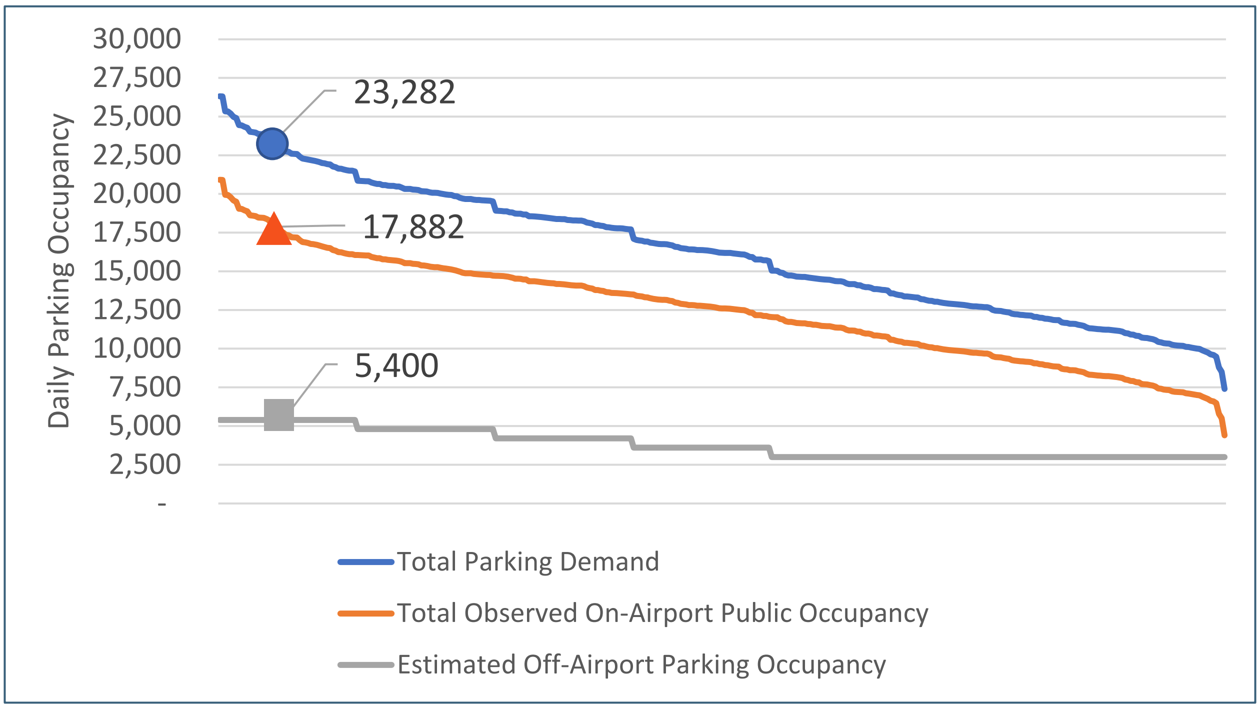
	Base Year (2019)	PAL 1	PAL 2	PAL 3
Employee Parking	1,900	1,950	2,080	2,380
Delta Off-Airport Employees [1,2]	1,660	1,700	1,810	**2,070**

NOTES:
PAL – Planning Activity Level
1 The requirement was estimated from observed traffic activity in March 2021 and employee parking occupancy on the Silver Ramp in January 2021. Future studies should verify the Delta employee parking requirement.
2 Growth was based on forecasted Delta flight operations.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

3.1.2.2 Public Parking

The on-Airport public parking requirements were determined using MAC-provided parking occupancy data. Off-airport parking requirements were estimated based on an assumed off-Airport parking supply and an assumed peak period occupancy. Based on the sorted data, as shown on **Exhibit 3-3**, the 20th busiest day was then identified as the public parking design day. The total demand includes both on-airport and off-airport parking. The 20th busiest day is the industry standard for planning airport public parking requirements.

Exhibit 3-3: Sorted Public Parking Occupancy (2019)



SOURCE: Kimley-Horn and Associates, Inc., 2022.

To determine the existing public parking stall requirement, a 5% service factor was applied to the design day demand to account for known parking operation inefficiencies. The future public parking requirements were calculated by increasing the existing requirement at the same rate as the annual Origin and Destination O&D enplaned passengers. The off-Airport parking requirements were assumed to grow at the same rate as on-Airport parking demand.

Table 3-7 summarizes the public parking requirements. Public parking stall requirements are presented for the entire Airport, rather than by each individual terminal. Terminal-specific parking requirements will be further explored in the alternatives analysis. Detailed results can be found in **Appendix C.3**.

Table 3-7: Existing and Future Public Parking Requirements (Stalls)

	Base Year (2019)	PAL 1	PAL 2	PAL 3
On-Airport	18,800	21,090	22,640	25,900
Off-Airport	5,700	6,370	6,840	7,820
Total	**24,500**	**27,460**	**29,480**	**33,720**

NOTE:
PAL – Planning Activity Level
SOURCE: Kimley-Horn and Associates, Inc., 2022.

3.1.2.3 Total Airport Parking Requirement

The total Airport parking requirement comprises the on-Airport public parking requirement, the off-Airport public parking requirement, and the employee parking requirement. The requirements presented do not identify the demand allocated for T1 parking, T2 parking, and off-Airport parking products. For estimates of terminal-specific requirements at PAL 1, refer to **Appendix C.3**. Without a preferred terminal alternative, it is not possible to accurately measure terminal-specific parking demand. As such, terminal-specific requirements will be assessed as part of the alternatives analysis and will be based on forecast flight activity at each terminal.

Proposed private developments south of the Airport are anticipated to reduce the off-Airport parking supply. It was assumed that off-Airport parking customers would use on-Airport parking when the off-Airport parking demand exceeds the available supply, thus increasing the on-Airport parking requirement. Various parking supply scenarios were analyzed to estimate the future surplus or deficit when compared with existing conditions. The following are the supply scenarios analyzed:

- *Supply Stage 1:* Existing – Stage 1 assumes all existing MAC parking facilities are open and no developments have impacted the supply of off-Airport operators. **Table 3-8** provides the estimated surplus/deficit for Stage 1.
- *Supply Stage 2:* Off-Airport development and Red/Blue Ramps Capital Improvement Program (CIP) – Stage 2 assumes off-Airport developments have reduced the private operator parking supply (1,000-stall loss). This stage also assumes the Red and Blue Ramps Levels 2 and 3 are converted to public parking (1,700-stall gain). **Table 3-9** provides the estimated surplus/deficit for Stage 2.
- *Supply Stage 3:* Green/Gold Ramps demolition – In addition to the impacts to the parking supply from Supply Stage 2, Stage 3 accounts for the loss of on-Airport parking with the demolition of the Valet Ramp and Green and Gold Ramps (7,950-stall loss). It also includes the reduction of off-Airport parking supply with the loss of the Park 'N Go surface lot and the Park 'N Fly parking ramp (2,100-stall loss). **Table 3-10** provides the estimated surplus/deficit for Stage 3.

Table 3-8: Stage 1 Parking Surplus/Deficit

	Base Year (2019)	PAL 1	PAL 2	PAL 3
Total Parking Requirement (Public and Employee) [1]	**26,400**	**29,410**	**31,560**	**36,100**
Total Parking Supply	33,220			
Surplus/(Deficit)	6,820	3,810	1,660	(2,880)

NOTES:
PAL – Planning Activity Level
1 Does not include the Delta employee parking requirement.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

Table 3-9: Stage 2 Parking Surplus/Deficit

	Base Year (2019)	PAL 1	PAL 2	PAL 3
Total Parking Requirement (Public and Employee) [1]	**26,400**	**29,410**	**31,560**	**36,100**
Total Parking Supply	33,920			
Surplus/(Deficit)	N/A	4,510	2,360	(2,180)

NOTES:
PAL – Planning Activity Level; N/A – Not Applicable
1 Does not include the Delta employee parking requirement.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

Table 3-10: Stage 3 Parking Surplus/Deficit

	Base Year (2019)	PAL 1	PAL 2	PAL 3
Total Parking Requirement (Public and Employee) [1]	**26,400**	**29,410**	**31,560**	**36,100**
Total Parking Supply	23,870			
Surplus/(Deficit)	N/A	(5,540)	(7,690)	(12,230)

NOTES:
PAL – Planning Activity Level; N/A – Not Applicable
1 Does not include the Delta employee parking requirement.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

3.1.2.4 Electric Vehicle Parking Considerations

The current electric vehicle (EV) fleet has driven an increasing demand for EV charging infrastructure. Guidance for Evs set by the federal government, the State of Minnesota, and vehicle manufacturers informed the future EV charger uses and potential infrastructure requirements. The number of EV charging stalls needed for public and employee parking at MSP was estimated using a methodology based on vehicle sales. **Table 3-11** presents the recommended number of EV charging stalls to accommodate on-Airport public and employee parking. The analysis assumes 25% of EVs parked at MSP require concurrent charging.

Table 3-11: Electric Vehicle Charging Stall Requirements

	On-Airport Parking Requirement [1]	Percent EV Fleet	EV Charging Stall Requirement
PAL 1	24,410	3.1%	**191**
PAL 2	28,660	12.3%	**884**
PAL 3	33,200	42.0%	**3,485**

NOTES:
PAL – Planning Activity Level; EV – Electric Vehicle
1 The parking requirement includes the on-Airport public parking requirement, excess off-Airport requirement, and employee parking. It does not include the Delta employee parking requirement or off-Airport provided parking.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

Changes in driver habits, battery technology, charging technology, and available off-Airport charging options may alter the number of EVs needing access to an EV charger over the planning period, with considerations made for vehicles requiring different charging intensity based on the stay duration. A future study is recommended to explore the number of EV chargers at different levels (i.e., Level 1, Level 2, and direct-current [DC] fast charge) to provide a range of services that align with customer demand, while aligning electrical demand with the power grid. Refer to **Appendix C.3** for additional information on the electrification of vehicles.

3.1.3 Rental Car Facility Requirements

A survey from 2019 was used to gather rental car agency (RAC) data related to the number of return transactions per day, rental transactions per hour during an average day, and overall monthly activity. **Exhibit 3-4** illustrates the methodology used to determine rental car facility requirements.

Exhibit 3-4: Rental Car Facility Requirements Methodology

NOTE:
RAC – Rental Car Agency
SOURCE: Kimley-Horn and Associates, Inc., 2022.

Peak-hour rental and return activity was used to determine RAC facility requirements to provide a high level of customer service. The total activity assumed a 5% terminal-specific passenger surge above the historic Airport split, because T1 and T2 operations peak at different hours during the day. The rental car facility requirements were determined using the peak-hour rentals and returns, industry-standard surge factors, industry-standard sizing factors, and industry-standard transaction times. A 1.25 surge factor was applied to customer service counter positions, fueling positions, and wash bays to account for uneven activity distribution within the peak hour. Peak-hour returns and rentals grew at the same rate as O&D enplaned passenger growth at each PAL. **Table 3-12** presents the rental car facility requirements. Refer to **Appendix C.2** for a more detailed description of the methodology used and **Appendix C.3** for terminal-specific requirements at PAL 1. Future terminal-specific requirements will be assessed as part of the alternatives analysis and will be based on forecast flight activity at each terminal.

Table 3-12: Existing and Future Rental Car Facility Requirements

Customer Service Counter Positions	52	61	66	75
Fueling Positions	92	102	109	125
QTA Storage (On-Site Vehicles)	1,160	1,310	1,400	1,610

NOTES:
PAL – Planning Activity Level; QTA – Quick Turnaround
SOURCE: Kimley-Horn and Associates, Inc., 2022.

The results suggest the Airport has sufficient customer service positions and ready/return stalls through the planning period, but will face deficits for fueling positions, wash bays, and Quick Turn Around (QTA) storage space, as presented in **Table 3-13**.

Table 3-13: Rental Car Facility Surplus/Deficit

		Surplus/(Deficit)			
Facility	**Existing Supply**	**Base Year**	**PAL 1**	**PAL 2**	**PAL 3**
Customer Service Counter Positions	77	22	16	9	2
Ready/Return Stalls	2,715	1,065	860	725	440
Fueling Positions	100	8	(2)	(9)	(25)
Wash Bays	20	(4)	(6)	(7)	(12)
QTA Storage (On-Site Vehicles)	1,260	100	(50)	(140)	(350)

NOTES:
PAL – Planning Activity Level; QTA – Quick Turnaround
SOURCE: Kimley-Horn and Associates, Inc., 2022.

3.1.3.1 Electric Vehicle Rental Car Considerations

RACs have stated a business desire to convert their fleets to EVs, including one large national brand planning to convert its entire fleet by 2025. Aggressive corporate goals may not immediately manifest in greater rates of EVs within the fleet, but the trend toward fleet electrification should not be diminished due to the significant electrical loads associated with maintaining an all-EV fleet. By 2040, 96% of the rental car fleet is anticipated to be electric.

The shift in the rental car fleet toward Evs could change the turnaround process, as vehicles require electric fueling rather than gasoline fueling. The demand for EV chargers will be dependent on the agency's operational model. Three operational scenarios are feasible:

- *Ready/Return Charging*: This scenario assumes all Evs are charged in the ready/return area using either Level 2 chargers or a variety of Level 2 and DC fast chargers.
- *QTA Charging:* A QTA electric-fueling operation would parallel the existing operation, using DC fast chargers for power.

- *Ready/Return and QTA Charging:* Vehicles would be charged for a fixed time of 15 minutes in the QTA area using a DC fast charger. Vehicles requiring additional charging will be charged in the ready/return area using a Level 2 charger.

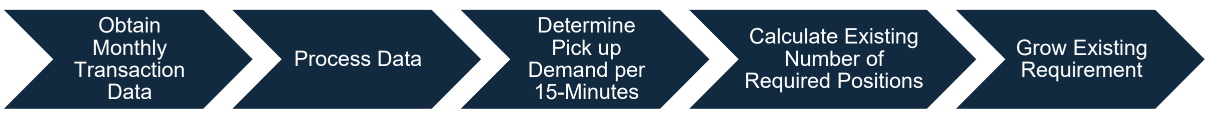
This study assumes EV charging in both the ready/return and QTA area based on preliminary input from RACs at peer airports. This assumption should be validated prior to new rental car facility development. Impacts to the number of electric and gasoline-fueling positions required for each RAC operational scenario are described in **Appendix C.3**.

3.1.4 Ground Transportation Center Requirements

The MAC provided the commercial ground transportation transaction data. The requirements analysis considered all commercial modes that currently operate at MSP. For the purposes of this report, on-demand ground transportation modes included TNCs, taxis, and limo services, whereas scheduled services accounted for the other commercial modes (shuttles and buses).

Exhibit 3-5 illustrates the general methodology used to determine the GTC requirements.

Exhibit 3-5: Ground Transportation Center Requirements Methodology



SOURCE: Kimley-Horn and Associates, Inc., 2022.

Monthly transaction data were aggregated and processed by the hour, day, and week. The hourly data was further distilled into 15-minute time periods. The 99th percentile, 15-minute activity level was used as the basis to determine the number of required vehicle positions. The number of required vehicle positions were determined using an average observed dwell time and a surge factor of 1.5 to account for sudden increases in activity. Refer to **Appendix C.2** for dwell times used for each commercial mode and detailed results.

The future on-demand commercial vehicle requirements were determined by growing the existing requirements by the peak-hour terminating passengers. Only terminating passengers were accounted for in the on-demand requirements because on-demand services typically only pick up passengers from the commercial curb.

The future scheduled service requirements were determined by growing the existing requirements by the peak-hour total flights. Scheduled services use the commercial curb for drop-off and pick-up, so both arriving and departing flights were considered in the peak hour.

Table 3-14 presents the existing and forecast baseline ground transportation requirements. By PAL 3, on-demand services will have a deficit of 7 positions and scheduled services will have a deficit of 10 positions. Several additional scenarios exploring the change in customer behavior through PAL 1 were analyzed, and detailed results can be found in **Appendix C.3**.

Table 3-14: Existing and Future Ground Transportation Facility Requirements

Ground Transportation Mode	Requirement (Number of Positions)	
	Base Year	PAL 3
Taxis	27	34
TNCs	45	56
Limousines	34	43
Shuttles	39	54
Buses	14	19
Total	**159**	**206**

NOTES:
PAL – Planning Activity Level; TNC – Transportation Network Company
1 Curbside requirements for PAL 2 are intentionally not presented. It is best practice to design curbside facilities to meet requirements at the end of the planning horizon.
SOURCE: Kimley-Horn and Associates, Inc., 2022.

3.2 TERMINAL

This section describes the gap analysis used to determine the types and quantities of facilities that will be needed to maintain or achieve the facility LOS goals at successive PALs. The gap analysis assumed no operational changes to the current state of the terminals. The current state of the terminals, as described in Chapter 1, includes terminal capital improvements that have been approved by the MAC and are under design or construction. Deficiencies and/or surpluses identified by the gap analysis guided the development of alternative concepts; however, the gap analysis by itself does not constitute a facility program since it does not consider capital improvements or operational changes to mitigate identified facility gaps.

3.2.1 Aircraft Parking Positions

The DDFS associated with PAL 2 and PAL 3 were gated (aircraft assigned to an existing or new gate position) to determine the number of aircraft parking positions required to accommodate passenger airline operations at each PAL. This analysis was completed prior to the onset of the COVID-19 pandemic and therefore does not use the updated DDFS.

The principal difference between the original and updated DDFS was the earlier retirement of aircraft with less than 50 seats that served the smaller markets in the original DDFS, which were replaced by 70-seat and larger aircraft (CRJ-700/CRJ-900). Therefore, markets with 3 to 4 daily flights that were served using 50-seat aircraft in the original DDFS were most likely replaced by 2 to 3 daily flights using CRJ-700/CRJ-900 aircraft in the updated DDFS. This difference was negligible and did not warrant updating the analysis.

3.2.1.1 Gated Design Day Flight Schedules

Each flight listed in the DDFS was gated using the following rules:

- Gate buffer times were set at 10 minutes (20-minute separation) to allow for taxi in/out and push back for Delta operations, with 15 minutes (30-minute separation) for all other non-Delta operations.
- A minimum of 60 minutes for tow on/off (departures and arrivals), flights with ground times greater than 3 hours (potential tow operations), and generic off-gate towing standards.

- The gating priorities were ranked 1 through 5, with 1 being the highest priority as 1) airline assignments, 2) international arrivals, 3) widebody operations, 4) remaining operations, and 5) regional/commuter gate priority, by Concourse C, then Concourses B and A, respectively.

Airline terminal assignments (on August 7, 2018) were as follows:

- T1 (except Concourse E): Air Choice One, Air France, Boutique Air, Delta, and KLM Royal Dutch Airlines
- T1 – Concourse E: Aer Lingus, Air Canada, Alaska Airlines, American Airlines, Spirit Airlines, and United Airlines
- T2: Condor, Frontier Airlines, Icelandair, JetBlue Airways, Southwest Airlines, and Sun Country

3.2.1.2 Findings from the Gated Design Day Flight Schedules

Table 3-15 summarizes the distribution of passenger airline operations among the three available terminal assignments over successive PALs. Overall, the DDFS reflects a 31% increase in airline operations from 2018 to PAL 3, with T2 experiencing the largest increase (89%) in total operations. **Table 3-16** presents the changes within different aircraft types (groups) among the three available terminal assignments over successive PALs. Overall, the DDFS shows regional aircraft operations decreasing from 66% of overall aircraft operations in 2018 to 32% by PAL 3.

Table 3-17 presents the changes in the number of gates that will be required to support enplaning and deplaning passengers for the three available terminal assignments. Overall, the DDFS show the number of aircraft gates required to support flight arrivals and departures increasing from 120 in 2018 to 140 by PAL 3. **Table 3-18** presents the average number of turns that will occur at the existing gates. A turn is defined as a flight arrival *or* departure, whereas a flight operation is defined as the combination of a flight arrival *and* departure.

The total number of aircraft parking positions that will be required to support the number of aircraft on the ground consists of aircraft gates used for enplaning/deplaning passengers and hardstand positions used to park aircraft that are on the ground but are towed off aircraft gates. According to **Table 3-19**, 18 off-gate hardstands are required by PAL 2 and 32 are required by PAL 3.

Table 3-15: Design Day Flight Schedule Passenger Airline Operations

Terminal	2018 [1]	PAL 2	PAL 3
T1 (except Concourse E)	900	1,016	1,140
T1 Concourse E	163	170	194
T2	110	184	208
Total Passenger Airlines	1,173	1,370	1,542

NOTE: PAL – Planning Activity Level
SOURCE: Ricondo & Associates, Inc., 2022.

Table 3-16: Design Day Flight Schedule Passenger Airline Operations by Aircraft Group

Terminal	2018	PAL 2	PAL 3
	Regional		
T1 (except Concourse E)	412	332	328
T1 Concourse E	54	72	46
T2	-	-	-
	Narrowbody		
T1 (except Concourse E)	470	634	762
T1 Concourse E	109	98	148
T2	108	182	206
	Widebody		
T1 (except Concourse E)	18	50	50
T1 Concourse E	-	-	-
T2	2	2	2

NOTES:
PAL – Planning Activity Level
1 Frontier Airlines operated from Concourse E in August 2018.
SOURCE: Ricondo & Associates, Inc., 2022.

Table 3-17: Aircraft Gate Demand

Terminal	Existing Gate Count	PAL 2	PAL 3
T1 (except Concourse E)	88	96	104
T1 Concourse E	16	16	16
T2	16	17	20

NOTE:
PAL – Planning Activity Level
SOURCE: Ricondo & Associates, Inc., 2022.

Table 3-18: Average Turns on Existing Gates

Terminal	2018	PAL 2	PAL 3
T1 (except Concourse E)	5.1	5.4	5.7
T1 Concourse E	5.1	5.2	5.9
T2	3.9	5.7	6.1

NOTE:
PAL – Planning Activity Level
SOURCE: Ricondo & Associates, Inc., 2022.

Table 3-19: Off-Gate Tow On/Off Hardstands

Terminal	PAL 2	PAL 3
T1 (except Concourse E)	6	12
T1 Concourse E	9	15
T2	3	5

NOTE:
PAL – Planning Activity Level
SOURCE: Ricondo & Associates, Inc., 2022.

3.2.2 Passenger Terminal Facility Planning Parameters

Planning parameters represent criteria specific to MSP passengers, airlines, agencies, and other stakeholders that were used to conduct the gap analysis for passenger terminal facilities. The four categories of criteria were the following:

- LOS standards define acceptable wait times for passengers needing a particular service and the amount of space provided to passengers waiting in queue for service.

- Passenger attributes refer to passenger habits, which include travel party size, ground transportation method, number of bags checked, and show-up profiles.
- Baseline terminal facilities, as described in Chapter 1, summarize the inventory of terminal facilities and resources most pertinent to the gap analysis, including all terminal capital improvements that have been approved by the MAC.
- Operating parameters define the types of services and transaction times.

A detailed discussion of the passenger terminal facility planning parameters used to develop the 2040 LTP is contained in **Appendix A**. Sources used to define the planning parameters included airline industry manuals and guidelines, MSP-specific studies, on-Airport passenger surveys conducted in March and August of 2019, and MSP stakeholder workshops conducted in the spring of 2020.

3.2.2.1 Level of Service Standards

LOS standards were used to define the key performance objectives for (a) passenger transaction wait times (transactions such as checking in, checking bags, and clearing security) and (b) the amount of space provided to passengers waiting in queue. LOS standard goals generally conform to “optimum design standards,” as recommended by the International Air Transport Association (IATA) in its *Airport Development Reference Manual*, 11th edition. Optimum design standards occur when facilities provide adequate space and reasonable delays, and the cost of maintenance and construction is equitable to facility utilization. The IATA LOS standard prescriptions were superseded by MAC-specific criteria or U.S. agency guidelines, where applicable. **Table 3-20** summarily lists the LOS standards used for the principal passenger terminal functional and waiting areas.

Table 3-20: Level of Service Standards

Function	Notes	Space (square feet per passenger)	Maximum Wait Time (minutes)
Check-in			
Self-Service Kiosk	Queue width 4.5–5.0 ft	14.0–19.4	<1
Bag-Drop	Queue width 4.5–5.0 ft	14.0–19.4	<3
Full-Service Economy	Queue width 4.5–5.0 ft	14.0–19.4	<10
Full-Service Premium	Queue width 4.5–5.0 ft	14.0–19.4	<5
Security Checkpoint Queue			
Standard Lane	Queue width 4.0 ft	10.8	<20
Expedited Screening Lane	Queue width 4.0 ft	10.8	<10
Holdrooms			
Seated	40% [1]	17.2	N/A
Standing	30%–40% [1]	11.9	N/A
Domestic Baggage Claim		16.2–18.3	20<
Federal Inspection Services			
International Baggage Claim		16.2–18.3	20<
Document Inspection	Queue width 4.5–5.0 ft	14.0–19.4 [2]	25<

NOTES:
N/A – Not Applicable
1 This accounts for 20% to 30% of passengers at nearby concessions.
2 This reflects the bag-first queue configuration.
SOURCES: International Air Transport Association, *Airport Development Reference Manual*, 11th edition, March 2019; Ricondo & Associates, Inc., 2022.

3.2.2.2 Passenger Attributes

Passenger attributes were described for the following airlines and airline groupings:

- Delta
- Sun Country
- Southwest
- Domestic Other Airlines (OALs): American, United, Spirit, Frontier, JetBlue, Alaska, Air Canada
- International OALs: Condor, Icelandair, Air France, KLM Royal Dutch Airlines, Aer Lingus

Attributes associated with passengers included the following:

- Travel party size – The number of passengers that share the same reservation code and conduct transactions as a group
- Well-wisher and meeter-greeter ratios – non-traveling friends and family who enter the terminal with departing passengers (well-wishers), or welcome arriving passengers (meeter-greeters)
- Passengers checking bags
- Show-up times at the Airport, prior to scheduled departure time

3.2.2.3 Operating Parameters

Operating parameters pertain to processing sequence and associated processing rates and rules for tenant use of facilities. Operating parameters also include minimum space configuration templates. Operating parameters and LOS standards are the principal considerations applied against demand to determine facility requirements.

For the gap analysis, the following operating parameters were used:

- Processing sequence for departing passengers, arriving domestic and arriving pre-cleared international passengers, and arriving international passengers
- Airline facilities, including –
  - Check-in locations
  - Check-in class eligibility
  - Check-in channels
  - Check-in transaction times
  - Outbound baggage makeup cart staging
  - Inbound baggage unloading
  - Airline crew size
- Transportation Security Administration (TSA)
  - Security Screening Checkpoint (SSCP) equipment types and screening rates
  - Checked Baggage Inspection Systems (CBIS) equipment and screening rates
- U.S. Customs and Border Protection (CBP)
  - Simplified Arrival

Airline terminal assignments are another important operating parameter. **Table 3-21** lists the airline terminal assignments as of spring 2020.

Table 3-21: Airline Terminal Assignments

T1	T2
Aer Lingus (EI)	Condor (DE)
Air Canada (AC)	Icelandair (FI)
Air Choice One (3E)	Frontier Airlines (F9)
Air France (AF)	JetBlue Airways (B6)
Alaska Airlines (AS)	Southwest Airlines (WN)
American Airlines (AA)	Sun Country Airlines (SY)
Boutique Air (4B)	
Delta Air Lines (DL)	
KLM Royal Dutch Airlines (KL)	
Spirit Airlines (NK)	
United Airlines (UA)	

NOTE:
The airline terminal assignments represent spring 2020.
SOURCE: Ricondo & Associates, Inc., 2022.

3.2.3 Passenger Terminal Facility Gap Analysis

The passenger terminal facility gap analysis provides an initial determination of the types and quantities of facilities that will be needed to maintain or achieve the MAC-provided LOS goals at successive PALs. The detailed gap analysis completed in June 2020 is included in **Appendix A**. Like the gap analysis for aircraft parking positions, the terminal facility gap analysis was completed prior to the onset of the COVID-19 pandemic, with the differences between the original DDFS and the updated DDFS not deemed significant enough to revise this analysis.

Terminal facility needs were primarily assessed by identifying peak-hour passenger demand (the hour in the day that has the greatest passenger activity) and flight scheduling patterns (how the airlines distribute flights), rather than annual activity (the total passengers the terminal processes for the year). Peak-hour passenger demand was derived from the DDFS discussed in Chapter 2. The DDFS provided information on a flight-by-flight basis for flight arrival and departure times, operating airline, terminal and gate location, aircraft type, points of origin and destination, seat capacity, load factor, and originating/terminating percentage.

The following subsections summarize the future terminal facility requirements from the passenger terminal facility gap analysis.

3.2.3.1 Check-in Facilities

Passenger demand for check-in facilities at T1 and T2 was modeled using computer simulation software that applied planning criteria, including show-up profiles and processing rates, to determine the number and types of check-in units that would be needed to maintain prescribed LOS standards for check-in. **Table 3-22**, **Table 3-23**, and **Table 1-24** list the required number of check-in positions for each terminal, airline, and airline partners. Summarily, the results from the gap analysis were as follows:

- T1: LOS is met at all PALs. The mix of check-in positions between bag-drop and agent counter may need to be redistributed.
- T2: Kiosk deficiencies exist at PAL 1 (assuming proprietary units).

Table 3-22: T1 Check-in Requirements – Delta and SkyTeam

Delta and SkyTeam Peak-Hour Originating Passengers (at show-up time)		Units	Inventory	PAL 1	PAL 2	PAL 3
		PAX	--	2,575	2,906	3,643
Peak-Hour Check-in Demand		PAX	--	688	687	842
Main Terminal	Kiosks	Units	48	27	35	35
	Sky Priority Agents	Positions	7	2	2	2
	Special Services Agents	Positions	14	5	5	5
	Bag-Drop Positions	Positions	14	13	15	20
	Total Bag-Drop/Agent	**Positions**	**35**	**20**	**22**	**27**
Curb	Kiosks	Units	5	9	12	13
	Agent Counters	Positions	10	4	5	6
Tram Level		Positions		12	7	9

NOTES:
Numbers in red denote deficiencies in an acceptable level of service.
PAL – Planning Activity Level; PAX – Passengers
SOURCE: Ricondo & Associates, Inc., June 2020.

Table 3-23: T1 Check-in Requirements – Other Airlines

T1 OTHER AIRLINES Peak-Hour Originating Passengers (at show-up time)		Units	Inventory	PAL 1	PAL 2	PAL 3
		PAX		1,156	1,248	1,337
Peak-Hour Check-in Demand		PAX	--	860	957	1,028
Kiosks	Air Canada	Units	4	3	4	4
	American Airlines	Units	20	13	13	18
	United Airlines	Units	16	10	10	11
	Common Use (AS, EI, NK, EAS)	Units	24	10	13	13
Bag-Drop Positions	American Airlines	Positions	6	4	4	6
	United Airlines	Positions	4	3	3	3
	Common Use (AS, EI, NK, EAS)	Positions	8	6	10	8
	Aer Lingus (Premium Only)	Positions	2	2	2	2
Agent Counter Positions	Air Canada	Positions	4	4	4	4
	Alaska Airlines (Premium Only)	Positions	2	2	2	2
	American Airlines	Positions	4	4	4	4
	Spirit Airlines	Positions	4	2	2	2
	United Airlines	Positions	6	4	4	4
	Unassigned Positions	Positions	2	--	--	--
Total Bag-Drop/Agent Positions		Positions	42	31	35	35

NOTES:
EAS – Essential Air Service (Air Choice One, Boutique Air); AS – Alaska Airlines; EI – Aer Lingus; NK – Spirit Airlines; PAL – Planning Activity Level; PAX – Passengers
SOURCE: Ricondo & Associates, Inc., June 2020.

Table 3-24: T2 Check-in Requirements

TERMINAL 2 – All Airlines Peak-Hour Originating Passengers (at show-up time)		Units	Inventory	PAL 1	PAL 2	PAL 3
		PAX	--	1,156	1,248	1,337
Peak-Hour Check-in Demand		PAX	--	860	957	1,028
Kiosks	Frontier Airlines	Units	3	10	10	10
	JetBlue Airways	Units	3	5	7	7
	Southwest Airlines	Units	10	14	14	17
Agent Counter Positions	Sun Country Airlines	Positions	28	15	17	20
	Condor	Positions	6	6	6	6
	Icelandair	Positions	6	5	5	5
	Frontier Airlines	Positions	6	4	4	4
	JetBlue Airways	Positions	6	4	4	4
	Southwest Airlines	Positions	14	9	9	11
Total Agent Positions		Positions	58	43	45	50

NOTES:
Agent Counters at T2 are common use and can fluctuate usage throughout the day.
PAL – Planning Activity Level; PAX – Passengers
SOURCE: Ricondo & Associates, Inc., June 2020.

3.2.3.2 Transportation Security Administration Passenger Security Screening Checkpoints

Computer simulation was used to evaluate the performance of the TSA SSCPs. Each PAL was simulated to determine the resulting security wait times and to estimate the number of passengers waiting in queue. Demand at the SSCPs was conditioned on passengers being able to complete their check-in transactions within the prescribed LOS wait times for check-in. The baseline condition assumed Automated Screening Lane (ASL) technology at the T1 SSCPs and non-ASL technology at the T2 SSCPs.

In addition to the summer DDFS (August), a spring DDFS (March) was evaluated using 2018 TSA throughput data. **Table 3-25** and **Table 3-26** list the required number of checkpoint lanes for each terminal. Summarily, the results from the gap analysis were as follows:

- T1: Under baseline conditions (ASL) and computed tomography X-ray [CTX]), the wait time goal of 10 minutes is exceeded by 1 to 2 minutes in PAL 3. With the addition of remote resolution, wait times are not exceeded and fewer passenger screening lanes are used.
- T1 Spring Sensitivity: Under baseline conditions (ASL and CTX), the T1 SSCPs cannot achieve the desired LOS, resulting in up to 30 minutes of wait time and overflowing queues. The addition of remote resolution will ensure wait time goals are met and queues are not exceeded.
- T2: Under baseline conditions (non-ASL), the wait time goal of 10 minutes is exceeded by 4 to 5 minutes in PAL 3. With the use of ASLs, wait time goals are met. Remote resolution would result in lower lane usage.
- T2 Spring Sensitivity: Under baseline conditions (non-ASL), the T2 SSCPs cannot achieve the desired LOS, resulting in over 30 minutes of wait time and overflowing queues. The addition of ASLs and CTX reduces the wait time and queue length, but it still does not meet the desired LOS. LOS is met with the addition of remote resolution.

Table 3-25: T1 Security Screening Checkpoint Requirements

Planning Activity Level	Peak-Hour Originating Passengers	Peak-Hour SSCP Demand (PAX)	SSCP	PAX Lanes Used	Expedited Passengers		Standard Passengers	
					Wait Time	Passengers in Queue	Wait Time	Passengers in Queue
ASL + CTX								
PAL 1	3,388	2,604	South	8	4:33	70	9:25	114
			North	8	4:38	51	9:40	122
PAL 2	3,558	2,752	South	8	5:04	73	9:45	127
			North	8	5:05	68	9:22	137
PAL 3	4,399	3,140	South	8	5:01	71	11:08	171
			North	8	5:03	91	11:14	136
ASL + CTX + Remote Resolution								
PAL 1	3,388	2,604	South	7	5:03	86	9:36	142
			North	7	5:09	60	9:38	138
PAL 2	3,558	2,752	South	7	4:49	85	9:50	124
			North	7	4:53	67	9:49	148
PAL 3	4,399	3,140	South	7	5:01	88	9:32	129
			North	7	5:04	93	9:43	159
Spring Break with ASL + CTX + Remote Resolution								
2018		4,301	South	7	5:01	88	10:45	145
			North	8	4:49	97	10:48	145

NOTES:
Numbers in red denote deficiencies in an acceptable level of service; Peak-Hour Originating Passengers: at scheduled departure time; Expedited Queue Capacity – South: 90 passengers; North: 108 passengers; Standard Queue Capacity – South: 190 passengers; North: 271 passengers
ASL – Automated Screening Lane; CTX – Computed Tomography X-ray; PAL – Planning Activity Level; PAX – Passengers; SSCP – Security Screening Checkpoint
SOURCE: Ricondo & Associates, Inc., May 2020.

Table 3-26: T2 Passenger Security Screening Checkpoint Requirements

Planning Activity Level	Peak-Hour Originating Passengers	Peak-Hour SSCP Demand (PAX)	PAX Lanes Used	Expedited Wait Time	Standard Wait Time	Passengers in Queue
Non-ASL						
PAL 1	1,156	1,107	7	4:50	9:09	136
PAL 2	1,248	1,158	7	4:41	9:14	141
PAL 3	1,337	1,282	7	4:30	14:23	201
ASL + CTX						
PAL 1	1,156	1,107	7	4:50	9:09	144
PAL 2	1,248	1,158	7	4:41	9:35	142
PAL 3	1,337	1,282	7	4:30	9:32	156
ASL + CTX + Remote Resolution						
PAL 1	1,156	1,107	5	4:44	9:39	128
PAL 2	1,248	1,158	5	5:01	9:15	129
PAL 3	1,337	1,282	5	4:55	8:01	144
Spring Break with ASL + CTX + Remote Resolution						
2018		1,734	6	4:10	8:33	183

NOTES:
Queue Capacity: 305 passengers; Numbers in red denote deficiencies in an acceptable level of service.
ASL – Automated Screening Lane; CTX – Computed Tomography X-ray; SSCP – Security Screening Checkpoint; PAL – Planning Activity Level; PAX – Passengers
SOURCE: Ricondo & Associates, Inc., May 2020.

3.2.3.3 Transportation Security Administration Checked Baggage Inspection System

The CBIS requirements were determined using the DDFS originating passenger demand and the average number of bags per passenger. Equipment requirements were not based on average baggage flows; rather, they were based on surged flows, obtained by applying a surge factor to a 10-minute bag demand derived from the DDFS (per TSA guidelines). **Table 3-27** lists the required number of checkpoint lanes for each terminal. The results from the gap analysis showed that by P AL 1, one additional screening device is needed at T2.

Table 3-27: Centralized Baggage Inspection Systems

	Terminal	Inventory	PAL 1	PAL 2	PAL 3
T1	10-Min Bag Demand	Capacity: 674	287	320	366
	Number of Devices	6	4	5	5
T2	10-Min Bag Demand	Capacity: 225	135	147	156
	Number of Devices	**2**	**3**	**3**	**3**

NOTES:
Numbers in red denote deficiencies in an acceptable level of service.
PAL – Planning Activity Level; T1 – Terminal 1; T2 – Terminal 2
SOURCE: Ricondo & Associates, Inc., June 2020.

3.2.3.4 Outbound Baggage Makeup Facilities

Requirements for outbound baggage makeup facilities principally pertain to the number and capacity of bag makeup devices (typically bag carousels, piers, or slides) that receive and accumulate checked bags prior to being loaded on to baggage carts or containers for delivery to outbound aircraft. **Table 3-28** lists the peak flights in makeup and the peak carts staged for each terminal.

Table 3-28: Outbound Baggage Makeup

		Capacity	PAL 1	PAL 2	PAL 3
T1	Peak Flights in Makeup		78	85	100
	Peak Carts Staged	189	159	167	203
T2	Peak Flights in Makeup		16	17	17
	Peak Carts Staged	**64**	**62**	**68**	**66**

NOTES:
Numbers in red denote deficiencies in an acceptable level of service.
PAL – Planning Activity Level; T1 – Terminal 1; T2 – Terminal 2
SOURCE: Ricondo & Associates, Inc., June 2020.

3.2.3.5 Holdrooms

Holdroom spatial requirements were calculated using the MAC standards for minimum and high LOS. The requirements listed by concourse in **Table 3-29** reflect the largest aircraft anticipated to serve each gate through PAL 3.

Table 3-29: Holdroom Requirements

Concourse	Inventory			Level of Service (PAL 3)	
	Gates	Avg. Holdroom Area (Sq Ft)	Total Holdroom Area (Sq. Ft.)	Minimum (Sq. Ft.)	High (Sq. Ft.)
A	11	738	8,121	13,585	13,926
B	9	992	8,929	11,594	11,871
C	26	1,800	46,806	40,274	43,682
D	6	2,011	12,067	11,106	12,047
E	16	1,805	28,883	33,906	36,874
F	16	2,188	35,011	38,071	41,512
G	20	2,018	40,359	47,464	51,543
T2	**14**	**4,698**	**65,777**	**41,539**	**45,207**

NOTES:
Passenger capacity is based on 15 square feet per passenger (seated/standing blend).
Numbers in red denote deficiencies in an acceptable level of service.
T2 – Terminal 2; Pax – Passenger
SOURCE: Ricondo & Associates, Inc., June 2020.

3.2.3.6 Domestic Baggage Claim

A computer simulation was used to evaluate the performance of the Airport's domestic baggage claims. Each PAL was simulated to determine the resulting number of passengers waiting at bag claim and the baggage accumulation. Passengers are typically the driver for domestic baggage claim requirements, as most passengers typically arrive at the carousels before the bags arrive. The analysis is predicated on last-bag delivery occurring within 20 minutes of flight arrival. Passengers are metered by the unloading rate of the aircraft and the walking distance from their gate to the claim hall. Table 3-30 lists the required number of domestic bag claim units for each terminal.

Table 3-30: Peak Domestic Baggage Claim Demand by Planning Activity Level

	Peak 10-Minute Demand	Inventory	PAL 1	PAL 2	PAL 3
T1	Flights at Claim	--	17	18	27
	Passengers at Claim	--	377	399	718
	Carousels in Use	11	11	11	11
T2	Flights at Claim	--	7	7	8
	Passengers at Claim	--	135	273	224
	Carousels in Use	**4**	**4**	**4**	**4**

NOTES:
PAL – Planning Activity Level
T1 – Terminal 1; T2 – Terminal 2
SOURCE: Ricondo & Associates, Inc., June 2020.

3.2.3.7 Customs and Border Protection – International Arrivals Facilities

Computer simulation was used to determine the international arrivals facilities and queue areas needed to achieve the LOS standards at each PAL. This included primary inspection, international baggage claim, and the re-check SSCP for international-to-domestic connecting passengers (T1 only). Demand at downstream processes was predicated on passengers being able to complete upstream processes within the prescribed LOS wait times and the last-bag delivery occurring within 20 minutes of flight arrival. The highest 30-minute demand at T1 occurs at PAL 2, which equates to four widebody aircraft in 20 minutes. While there are more international flight arrivals during spring (March/April) at the terminal, the highest peak demand occurs in summer. The summer international demand basis for T2 equates to one narrowbody and one widebody aircraft arriving within 20 minutes.

All simulations assume the CBP Simplified Arrival process, which uses biometric facial recognition technologies. The Simplified Arrival process eliminates the Automated Passport Control (APC) and exit control functions. For new international arrivals facilities, CBP could require facilities to conform to the “bag-first” configuration, as opposed to the current MSP configuration where passengers process through primary inspection prior to bag claim (officer first). Consequently, both the officer-first and bag-first configurations were simulated. **Table 3-31** and **Table 3-32** list the required primary inspection facilities for each terminal.

Table 3-31: T1 Primary Inspection Requirements

T1	Unit	Inventory	Officer First PAL2, PAL3	Bag First PAL2, PAL3
Peak 30-Min Passengers	Passengers	--	1,117	1,117
Global Entry APC Kiosks	Units	8	7	7
CBPO Positions – Global Entry	Booth/Podium	--	1	2
CBPO Positions – Mobile Passport Control	Booth/Podium	--	2	1
CBPO Positions – U.S. Citizens	Booth/Podium	--	11	10
CBPO Positions – Visitors	Booth/Podium	--	7	7
Total CBPO Positions	Booth/Podium	14	21	20
Passengers in Queue	Passengers	Officer First: 445	525	--
		Bag First: 296	--	383
Queue Area	**Square Feet**	**5,750**	6,772	7,430

NOTES:
Both PAL 2 and PAL have the same requirements
APC – Automated Passport Control; CBPO – Customs and Border Protection Officer
SOURCE: Ricondo & Associates, Inc., June 2020.

Table 3-32: T2 Primary Inspection Requirements

T2	Unit	Inventory	Officer First PAL2, PAL3	Bag First PLA2, PAL3
Peak 30-Min Passengers	Passengers	--	462	462
Global Entry APC Kiosks	Units	4	3	4
CBPO Positions – Global Entry	Booth/Podium	--	1	1
CBPO Positions – Mobile Passport Control	Booth/Podium	--	1	1
CBPO Positions – U.S. Citizens	Booth/Podium	--	4	4
CBPO Positions – Visitors	Booth/Podium	--	3	3
Total CBPO Positions	Booth/Podium	12	9	9
Passengers in Queue	Passengers	Officer First: 381	146	--
		Bag First: 254	--	150
Queue Area	**Square Feet**	**4,920**	**1,883**	**2,910**

NOTES:
Both PAL 2 and PAL have the same requirements
APC – Automated Passport Control; CBPO – Customs and Border Protection Officer
SOURCE: Ricondo & Associates, Inc., June 2020.

3.2.3.8 International Baggage Claim

Computer simulation was used to analyze the adequacy of the existing international baggage claim devices at each terminal. The results from the gap analysis were as follows:

- **Exhibit 3-6** shows the T1 international baggage claim facility can achieve LOS C in the officer-first and bag-first configurations when bags arrive within 20 minutes (both scenarios) and wait time goals are met at primary inspection (officer-first scenario).
- Because of the unique condition at T2 where domestic Bag Claim Devices (BCDs) A and B are partitioned off for international arrivals, domestic and international arrivals were simulated simultaneously to ensure there are no conflicts. The analysis for T2 used the spring schedule to analyze international bag claim since there are more international flights occurring in spring. **Exhibit 3-7** shows the T2 international baggage claim facility can achieve LOS C in the officer-first and bag-first configurations when bags arrive within 20 minutes (both scenarios) and wait time goals are met at primary inspection (officer-first scenario).

3.2.3.9 T1 Transportation Security Administration – Passenger Security Screening Checkpoint 7

After completing the process at the international arrivals facility, passengers who are connecting to a domestic flight are rescreened at TSA SSCP 7. **Table 3-33** shows that SSCP 7 has a shortfall of up to three screening lanes to process international connecting passengers by PAL 2.

Table 3-33: T1 Passenger Security Screening Checkpoint 7 (International Arrivals)

Scenario	Peak 30 Minute Arriving International Passengers	Number of Screening Lanes	Wait Time (LOS: 10 Minutes)	Passengers in Queue
Base Simulation				
Non-ASL	1,117	3	49:47	381
Requirements Simulations				
Non-ASL	1,117	6	9:56	189
ASL + CTX	1,117	5	9:59	**190**

NOTES:
Queue Capacity: 80 passengers
Numbers in red denote deficiencies in an acceptable level of service.
Existing: 3 non-ASL screening lanes
ASL – Automated Screening Lane; CTX – Computed Tomography X-ray; LOS – Level of Service
SOURCE: Ricondo & Associates, Inc., June 2020.

Exhibit 3-6: T1 International Baggage Claim Performance (Bag First)

Chart 1 - Diurnal Flights at Claim

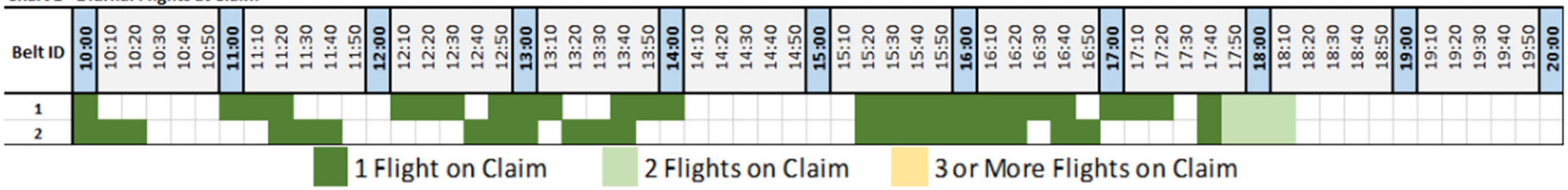


Chart 2 - Pax at Claim

Belt ID	10:00	10:10	10:20	10:30	10:40	10:50	11:00	11:10	11:20	11:30	11:40	11:50	12:00	12:10	12:20	12:30	12:40	12:50	13:00	13:10	13:20
1	48	0	0	0	0	0	0	83	89	0	0	0	0	0	84	157	122	0	136	155	3
2	13	147	141	0	0	0	0	0	0	139	170	90	0	0	0	0	14	162	158	1	13

Belt ID	13:30	13:40	13:50	14:00	14:10	14:20	14:30	14:40	14:50	15:00	15:10	15:20	15:30	15:40	15:50	16:00	16:10	16:20	16:30	16:40	16:50
1	0	41	155	156	0	0	0	0	0	0	0	14	152	155	60	154	154	0	32	33	0
2	159	162	0	0	0	0	0	0	0	0	0	9	137	144	0	75	158	117	0	34	46

Belt ID	17:00	17:10	17:20	17:30	17:40	17:50	18:00	18:10	18:20	18:30	18:40	18:50	19:00	19:10	19:20	19:30	19:40	19:50	20:00
1	0	138	168	51	0	74	290	280	31	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	78	265	251	1	0	0	0	0	0	0	0	0	0	0

Chart 3 - Bags at Claim

Belt ID	10:00	10:10	10:20	10:30	10:40	10:50	11:00	11:10	11:20	11:30	11:40	11:50	12:00	12:10	12:20	12:30	12:40	12:50	13:00	13:10	13:20
1	17	0	0	0	0	0	0	0	18	0	0	0	0	0	0	42	25	0	0	29	3
2	0	28	33	0	0	0	0	0	0	0	52	23	0	0	0	0	0	32	38	1	0

Belt ID	13:30	13:40	13:50	14:00	14:10	14:20	14:30	14:40	14:50	15:00	15:10	15:20	15:30	15:40	15:50	16:00	16:10	16:20	16:30	16:40	16:50
1	0	0	45	45	0	0	0	0	0	0	0	0	31	37	1	44	44	0	0	17	0
2	26	33	0	0	0	0	0	0	0	0	0	0	29	47	0	0	33	20	0	0	17

Belt ID	17:00	17:10	17:20	17:30	17:40	17:50	18:00	18:10	18:20	18:30	18:40	18:50	19:00	19:10	19:20	19:30	19:40	19:50	20:00
1	0	0	59	17	0	0	52	56	16	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	31	51	1	0	0	0	0	0	0	0	0	0	0

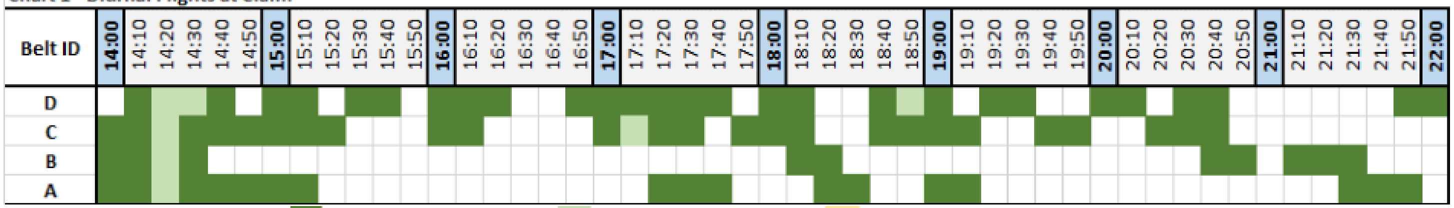
Legend	
(green)	= < 75% capacity
(yellow)	= 75% to 100% capacity
(orange)	= > 100% capacity

Peak 10-Minutes:
555 Passengers in Claim Hall

NOTE:
Pax – Passengers
SOURCE: Ricondo & Associates, Inc., June 2020.

Exhibit 3-7: T2 International/Domestic Baggage Claim Performance (Bag First)

Chart 1 - Diurnal Flights at Claim



1 Flight on Claim
2 Flights on Claim
3 or More Flights on Claim

Chart 2 - Pax at Claim

Belt ID	14:00	14:10	14:20	14:30	14:40	14:50	15:00	15:10	15:20	15:30	15:40	15:50	16:00	16:10	16:20	16:30	16:40	16:50	17:00	17:10	17:20	17:30	17:40	17:50
D	35	15	35	45	39	38	17	43	0	17	41	15	0	41	41	0	0	12	43	29	38	0	33	34
C	39	16	22	59	37	34	32	38	37	0	0	0	19	40	0	0	0	0	0	50	51	41	0	0
B	40	20	35	44	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	38	31	43	37	36	0	46	56	0	0	0	0	0	0	0	0	0	0	0	0	0	49	61	0

Belt ID	18:00	18:10	18:20	18:30	18:40	18:50	19:00	19:10	19:20	19:30	19:40	19:50	20:00	20:10	20:20	20:30	20:40	20:50	21:00	21:10	21:20	21:30	21:40	21:50	22:00
D	20	49	0	0	13	33	46	28	14	37	0	0	20	41	3	0	36	33	0	0	0	0	0	0	37
C	40	36	0	0	0	38	38	36	36	0	0	40	40	0	0	40	39	0	0	0	0	0	0	0	0
B	0	43	94	0	0	0	0	0	0	0	0	0	0	0	0	0	15	46	4	0	33	42	0	0	0
A	0	0	25	65	36	0	17	54	7	0	0	0	0	0	0	0	0	0	0	0	0	0	38	44	0

Chart 3 - Bags at Claim

Belt ID	14:00	14:10	14:20	14:30	14:40	14:50	15:00	15:10	15:20	15:30	15:40	15:50	16:00	16:10	16:20	16:30	16:40	16:50	17:00	17:10	17:20	17:30	17:40	17:50
D	16	0	4	8	4	5	0	3	0	0	14	6	0	11	18	0	0	0	22	3	8	0	13	14
C	16	0	2	2	1	2	2	10	7	0	0	0	0	9	0	0	0	0	0	12	17	2	0	0
B	6	0	2	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	61	0
A	2	1	2	2	8	0	46	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Belt ID	18:00	18:10	18:20	18:30	18:40	18:50	19:00	19:10	19:20	19:30	19:40	19:50	20:00	20:10	20:20	20:30	20:40	20:50	21:00	21:10	21:20	21:30	21:40	21:50	22:00
D	0	7	0	0	0	15	2	1	0	9	0	0	0	12	1	0	3	1	0	0	0	0	0	0	12
C	8	13	0	0	0	4	4	8	6	0	0	13	13	0	0	7	12	0	0	0	0	0	0	0	0
B	0	43	94	0	0	0	17	54	7	0	0	0	0	0	0	0	0	14	1	0	33	42	0	0	0
A	0	0	25	65	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	38	44	0

Legend
= < 75% capacity
= 75% to 100% capacity
= > 100% capacity

International Legend
= < 75% capacity
= 75% to 100% capacity
= > 100% capacity

Peak 10-Minutes:

119 International Passengers in Claim Hall

NOTE:
Pax – Passengers
SOURCE: Ricondo & Associates, Inc., June 2020.

3.3 AIRFIELD

This section describes the airside facility requirements needed at MSP to accommodate the current and forecasted demand through the 2040 LTP horizon. This section evaluates the required dimensional standards of various airside geometric elements against existing conditions, as noted in the inventory. Airfield capacity and incident/incursion histories are also discussed.

This analysis evaluated the following existing and future airside facility requirements:

- Airport Reference Code (ARC) / Critical Design Aircraft
- Runway Geometric Standards
  - Runway width
  - Runway Safety Area (RSA)
  - Runway Object-Free Area (ROFA)
  - Obstacle-Free Zone (OFZ)
  - Runway Protection Zone (RPZ)
  - Parallel runway separation
  - Runway to hold line separation
  - Runway to taxiway separation
- Taxiway Geometric Standards
  - Taxiway Design Group (TDG)
  - Taxiway width and shoulder width
  - Taxiway separation
  - Taxiway Safety Area (TSA)
  - Taxiway Edge Safety Margin (TESM)
  - Taxiway/Taxilane Object-Free Area (TOFA/TLOFA)
- Navigational Aid (NAVAID) Critical Areas
- Airfield Capacity
  - Runway length requirements
  - Takeoff length requirements
- Hot Spots, Incursion History, and Contributing Factors

3.3.1 Airport Reference Code (ARC) / Critical Design Aircraft

The Airport Reference Code (ARC) is an overall airport designation that relates airport design criteria to the operational and physical characteristics of the largest/most demanding aircraft type(s) that will operate at the airport. The ARC is made up of two components related to the critical design aircraft – which the FAA defines as the most demanding aircraft with greater than 500 annual operations.

The first component is related to the Aircraft Approach Category (AAC), represented by a letter A through E. The second component is the Airplane Design Group (ADG), represented by a roman numeral I through VI.

The existing critical design aircraft at MSP is the Airbus A330-900NEO, an ARC D-V aircraft. The future critical design aircraft has been identified as the Airbus A350-1000. The A350-1000 is the most demanding aircraft with forecast operations greater than 500 per year. This is based on the PAL 3 summer DDFS, which includes 24 operations for the A350-1000 in the design day. The

A350-1000 is an AAC D and ADG V aircraft, which aligns with the existing airfield's D-V designation. The A330-900NEO is TDG 5, while the A350-1000 is TDG 6. Consideration should be given to future taxiway/taxilane design to accommodate this change in TDG standard. **Table 3-34** summarizes the existing and future critical design aircraft specifications.

Table 3-34: Critical Design Aircraft Specifications

Aircraft	TDG	Wingspan	Tail Height
Airbus A330-900NEO	5	209.97 FT	**55.09 FT**
Airbus A350-1000	**6**	**212.42 FT**	**56.10 FT**

NOTE:
TDG – Taxiway Design Group
SOURCES: Manufacturer Data; U.S. Department of Transportation, FAA, Aircraft Characteristics Database, November 2022.

The AAC and ADG of an airport's critical design aircraft, when combined with a runway's approach visibility minimums, determines the Runway Design Code (RDC). The RDC establishes the minimum design standards for a particular runway and parallel taxiway, allowing safe operations for the critical design aircraft under specified weather conditions. The RDC is used for planning and design purposes and does not have any operational application. The Approach Reference Code (APRC) and Departure Reference Code (DPRC), as defined in **Chapter 1**, are operational designations for runways, specifically for runway-to-taxiway separations. A review of the APRC and DPRC standards was completed as a part of the LTP efforts. **Table 3-35** represents the existing and future RDC, APRC, and DPRC of each runway at MSP. Note the future change in critical design aircraft does not change any of these three standards. Since the APRC is dependent on a runway's lowest visibility minimums, different separation standards can apply depending on the runway configuration in use. **Section 3.3.2.9** reviews the runway-to-taxiway separations at MSP and discusses any substandard separations.

Table 3-35: Existing and Future RDC, APRC, and DPRC

Runway	RDC	APRC	DPRC
4	D-V	D/IV/2400 D/V/2400	D/IV, D/V
22	D-V	D/IV/4000 D/V/4000	D/IV, D/V
12L	D-V	D/IV/1200	D/IV, D/V
30R	D-V	D/IV/4000 D/V/4000	D/IV, D/V
12R	D-V	D/IV/1200	D/IV, D/V
30L	D-V	D/IV/1200	D/IV, D/V
17	D-V	D/IV/4000 D/V/4000	D/IV, D/V
35	D-V	D/IV/1200	D/IV, D/V

NOTES:
AAC – Aircraft Approach Category; ADG – Airplane Design Group; APRC – Approach Reference Code; DPRC – Departure Reference Code
SOURCE: HNTB Corporation, November 2022 (analysis).

3.3.2 Runway Geometric Standards

To maintain a safe airfield environment for aircraft to operate, the FAA has established safety and design standards for runways, taxiways, NAVAIDs, and adjacent land surrounding the runway system, as described in FAA Advisory Circular (AC) 150/5300-13B, *Airport Design*. This section describes the various design standards applicable to the Airport's airfield and areas of noncompliance with these standards (gaps). **Exhibit 3-10** graphically summarizes the deficiencies related to the airfield dimensional standards. **Section 3.3** and **Section 3.4** provide granular details regarding the required airfield standards and any deficiencies, with references to **Exhibit 3-10**, as applicable.

3.3.2.1 Runway Width

The required runway pavement width is dependent on the RDC and AAC-ADG combination for a given runway. All four runways at MSP will remain D-V runways with varying visibility minimums. Although visibility minimums are applicable to runway width in some cases, they do not apply to D-V runways. All D-V runways require 150-foot-wide runways, regardless of approach minimums. **Table 3-36** lists the required runway widths for each runway. All runways at MSP meet or exceed the required runway width for D-V.

Table 3-36: Runway Dimensions

Runway	4-22	12L-30R	12R-30L	17-35
Existing Width	150 FT	150 FT	200 FT	150 FT
Required Width	150 FT	150 FT	150 FT	150 FT
Deficiency	0	0	0	0

SOURCE: HNTB Corporation, November 2022 (analysis).

3.3.2.2 Declared Distances

As discussed in Section 1.4.2, declared distances effectively reduce the amount of runway available for takeoff, aborted takeoffs, and landings, so that adequate space exists for RSAs and ROFAs to mitigate unsuitable land use in the RPZ, or mitigate obstacles in the approach or departure path of an aircraft. **Table 3-37** presents the declared distances at MSP.

Table 3-37: Declared Distances

	Length	TORA	TODA	ASDA	LDA
Runway 4	11,006 FT	11,006 FT	11,006 FT	11,006 FT	9,456 FT
Runway 22	11,006 FT	11,006 FT	11,006 FT	11,006 FT	10,006 FT
Runway 12R	10,000 FT	10,000 FT	10,000 FT	10,000 FT	10,000 FT
Runway 30L	10,000 FT	10,000 FT	10,000 FT	10,000 FT	10,000 FT
Runway 12L	8,200 FT	8,200 FT	8,200 FT	7,620 FT	7,620 FT
Runway 30R	8,200 FT	8,200 FT	8,200 FT	8,200 FT	8,000 FT
Runway 17	8,000 FT	8,000 FT	8,000 FT	8,000 FT	8,000 FT
Runway 35	8,000 FT	8,000 FT	8,000 FT	8,000 FT	8,000 FT

NOTES:
TORA – Takeoff Run Available; TODA – Takeoff Distance Available; ASDA – Accelerate-Stop Distance Available; LDA – Landing Distance Available
SOURCE: HNTB Corporation, November 2022 (analysis).

3.3.2.3 Runway Safety Area

The RSA is a rectangular area surrounding the runway at the runway surface. Its purpose is to reduce the risk of damage to an aircraft in the event of an undershoot, overshoot, or excursion from the runway, as well as to provide adequate emergency vehicle access in such events. The RSA must be kept clear of objects, except for those identified as "fixed-by-function," such as runway and taxiway lights and signage, Precision Approach Path Indicators (PAPIs), or Approach Lighting Systems (ALSs). A review of existing RSA conformity was completed for each runway at

MSP. The RSA beyond the Runway 12L departure end (i.e., prior to the Runway 30R threshold) measures 420 feet beyond the departure end instead of the standard 1,000 feet. The RSA is constrained on this end of the runway by the Minnesota State Highway 5 off-ramp to the terminal access road. The RSA beyond the Runway 12R departure end (i.e., prior to the Runway 30L threshold) measures 830 feet beyond the departure end instead of the standard 1,000 feet. The RSA is constrained on this end of the runway by Northwest Drive and Route 5. **Table 3-38** summarizes the RSA non-conformities at MSP.

Table 3-38: Runway Safety Area Non-Conformities

RSA (Runway and Location)	Length to Standard	Object/Rationale	Existing Mitigation
Runway 12L departure end	580 FT	MN-5 off-ramp to the terminal access road	Declared distances
Runway 12R departure end	190 FT	Northwest Drive and MN-5	EMAS
Runway 30R approach end	200 FT	MN-5 off-ramp to the terminal access road	Displaced threshold

NOTES:
RSA – Runway Safety Area; MN – Minnesota; EMAS – Engineered Material Arresting System
SOURCE: HNTB Corporation, November 2022 (analysis).

The Runway 12L departure end RSA non-conformity is mitigated through declared distances. The non-conformity for the 30R approach is mitigated by a displaced threshold of 200 feet. The Runway 12R departure end RSA non-conformity is currently mitigated by an engineered material arresting system (EMAS) bed located beyond the Runway 12R departure end. At MSP, there are no objects identified within the RSAs that are not fixed-by-function. Standard RSA dimensions, including the standard RSA dimensions related to the use of declared distances, are dependent on a runway's RDC. These dimensions are noted in **Table 3-39.**

Table 3-39: Standard Runway Safety Area Dimensions

	RDC	RSA Length Prior to Runway Threshold	RSA Length Beyond Runway End	Width	Existing RSA Length Beyond Stop End
Runway 4	D-V-2400	600 FT	1,000 FT	500 FT	1,000 FT
Runway 22	D-V-4000	600 FT	1,000 FT	500 FT	1,000 FT
Runway 12L	D-V-700	600 FT	1,000 FT	500 FT	420 FT [1]
Runway 30R	D-V-4000	600 FT	1,000 FT	500 FT	1,000 FT
Runway 12R	D-V-600	600 FT	1,000 FT	500 FT	830 FT [2]
Runway 30L	D-V-1000	600 FT	1,000 FT	500 FT	1,000 FT
Runway 17	D-V-5500	600 FT	1,000 FT	500 FT	1,000 FT
Runway 35	D-V-600	600 FT	1,000 FT	500 FT	1,000 FT

NOTES:
RDC – Runway Design Code; RSA – Runway Safety Area
1 Declared distances (accelerate-stop distance available) are used to achieve the standard RSA length.
2 An engineered material arresting system (EMAS) bed is installed approximately 630 feet from the Runway 30L threshold.
SOURCE: HNTB Corporation, November 2022 (analysis).

3.3.2.4 Runway Object-Free Area

The ROFA is a rectangular area surrounding the runway and centered on the surface of the runway. Its purpose is to enhance the safety of aircraft by providing wingtip protection in the event of an aircraft excursion. ROFA standards are to be clear of all objects protruding above the elevation of the nearest point of the RSA, except for objects required to be within the ROFA due to their function (fixed-by-function). This includes the ground within the ROFA, which must be adequately graded so the ground does not protrude the RSA elevation.

Table 3-40 shows where there are deficiencies in standard ROFAs at MSP.

Table 3-40: Runway Object-Free Area Deficiencies

Exhibit 3-10 Index Number	ROFA	Deficiency [1]	Object
1	RWY 4-22 at RWY 12	150 FT	Wind Cone
2	RWY 4-22 at TAXIWAY M2	145 FT	ASOS
3	RWY 4-22 at TAXIWAY C / C1	150 FT	Wind Cone
4	RWY 4-22 at TAXIWAY L	100 FT	Pole
5	RWY 12L-30R at TAXIWAY M	150 FT	Wind Cone
6	RWY 12L-30R at TAXIWAY M	3 FT	Glideslope Shelter
7	RWY 12L-30R at RWY 30R End	150 FT	Wind Cone
8	RWY 12R-30L at TAXIWAY A9	150 FT	Wind Cone
9	RWY 12R-30L at TAXIWAY W2	7 FT	Glideslope Shelter
10	RWY 12R-30L at TAXIWAY A2	150 FT	Wind Cone
11	RWY 17 Approach	50 FT (to ROFA end)	Glideslope Shelter and Antenna
12	RWY 17-35 at TAXIWAY K8	150 FT	Wind Cone
13	RWY 17-35 at TAXIWAY K8	150 FT	ASOS
14	RWY 17-35 (south of TAXIWAY L3)	150 FT	Wind Cone
15	RWY 17-35 (south of TAXIWAY L3)	1 FT	Glideslope Shelter
16	RWY 35 Approach	60 FT	VSR
17	RWY 35 Approach	70 FT – 100 FT	ALSF-2 and 17 Localizer Shelter
18	RWY 35 Approach	70 FT – 100 FT	Various Poles

NOTES:
Exhibit Index Number refers to number labels in Exhibit 3-10
ROFA – Runway Object-Free Area; ASOS – Automated Surface Observing System; VSR – Vehicle Service Road; ALSF-2 – High-Intensity Approach Lighting System with Sequenced Flashing Lights
1 Deficiency signifies the distance from the object to the edge of the ROFA.
SOURCE: HNTB Corporation, November 2022 (analysis).

Like RSAs, standard ROFA dimensions are dependent on the RDC. **Table 3-41** presents the standard ROFA dimensions of the Airport's runways, which are based on existing declared distances.

Table 3-41: Standard Runway Object-Free Area Dimensions

	RDC	ROFA Length Prior to Runway Threshold	ROFA Length Beyond Runway End	Width	Existing ROFA Length Beyond Stop End
Runway 4	D-V-2400	600 FT	1,000 FT	800 FT	1,000 FT
Runway 22	D-V-4000	600 FT	1,000 FT	800 FT	1,000 FT
Runway 12L	D-V-700	600 FT	1,000 FT	800 FT	420 FT [1]
Runway 30R	D-V-4000	600 FT	1,000 FT	800 FT	1,000 FT
Runway 12R	D-V-600	600 FT	1,000 FT	800 FT	830 FT [2]
Runway 30L	D-V-1000	600 FT	1,000 FT	800 FT	1,000 FT
Runway 17	D-V-5500	600 FT	1,000 FT	800 FT	1,000 FT
Runway 35	D-V-600	600 FT	1,000 FT	800 FT	1,000 FT

NOTES:
RDC – Runway Design Code; ROFA – Runway Object-Free Area
1 Declared distances (accelerates-stop distance available) are used to achieve the standard ROFA length.
2 An engineered material arresting system (EMAS) bed is installed approximately 630 feet from the runway threshold.
SOURCE: HNTB Corporation, November 2022 (analysis).

3.3.2.5 Obstacle-Free Zone

The OFZ includes volumes of airspace comprising the runway OFZ (ROFZ), precision OFZ (POFZ), inner-approach OFZ (IA-OFZ), and inner-transitional OFZ (IT-OFZ). These surfaces do not allow for any object penetration or stationary aircraft, except for frangible NAVAIDs that are fixed-by-function.

Runway Obstacle-Free Zone

Per FAA AC 150/5300-13B, *Airport Design*, the standard ROFZ width for large aircraft is 400 feet and extends 200 feet beyond each runway end. All runways at MSP accommodate large aircraft. There are no objects identified within the ROFZs that are not fixed-by-function. **Table 3-42** presents the ROFZ dimensions at MSP.

Table 3-42: Standard Runway Obstacle-Free Zone Dimensions for Runways with Operations by Large Aircraft

	ROFZ Width	ROFZ Length
Runway 4-22	400 FT	11,406 FT
Runway 12L-30R	400 FT	8,600 FT
Runway 12R-30L	400 FT	10,400 FT
Runway 17-35	400 FT	8,400 FT

NOTE:
ROFZ – Runway Obstacle-Free Zone
SOURCE: HNTB Corporation, November 2022 (analysis).

Runway Precision Obstacle-Free Zone

The POFZ is a volume of airspace above an area beginning at the threshold elevation, with a width of 800 feet and extending 200 feet beyond the runway end. The POFZ only applies to runways with a vertically guided approach with landing minimums less than 250 feet above ground level (AGL), or visibility less than 0.75 statute miles, which includes Runways 4, 12L, 12R, 30L, and 35. The POFZ is only in effect when an aircraft is on final approach within 2 miles of the threshold. There are no objects identified at MSP within the POFZs that are not fixed-by-function.

Inner-Approach Obstacle-Free Zone

The IA-OFZ is only applicable to runways with an ALS, which includes all runways at MSP except Runway 17. The IA-OFZ begins 200 feet prior to the runway threshold at the same elevation, extending 200 feet beyond the last fixture in the ALS before rising at a slope of 50 to 1. No structures were identified that penetrate the sloped IA-OFZ surfaces. The runway hold bar locations were analyzed to ensure no portion of aircraft holding at a runway would penetrate the IA-OFZ, including the tail of the critical design aircraft (A330-900NEO with 55-foot tail height). There are no holding locations at MSP where parked aircraft tails penetrate the IA-OFZ.

Inner-Transitional Obstacle-Free Zone

The IT-OFZ is only applicable to runways with approach visibility minimums lower than 0.75 statute miles. The IT-OFZ extends perpendicular to the runway centerline from the edge of the ROFZ, starting at a formula-based elevation above the runway centerline elevation, dependent on critical design aircraft characteristics and sloping upward at a ratio of 6 to 1 until reaching the Code of Federal Regulations (CFR) Part 77 horizontal surface, which is 150 feet above the established Airport elevation. As with the IA-OFZ, no structures or aircraft positioned at runway hold bar locations were identified to penetrate the IT-OFZ surfaces. The 55-foot tail height and 210-foot wingspan of the A330-900NEO was used for this analysis.

3.3.2.6 Runway Protection Zone

The RPZ is a trapezoidal area at ground elevation prior to a runway landing threshold and beyond a runway departure end, centered on the runway centerline. In contrast to the RSA and ROFA, the purpose of the RPZ is to protect people and property on the ground at the runway ends in the event of an aircraft overshoot or undershoot.

There are two components of the RPZ: the approach RPZ and the departure RPZ. **Table 3-43** shows the approach and departure RPZ dimensions at MSP.

Table 3-43: Standard Runway Protection Zone Dimensions

	Length	Inner Width	Outer Width
Runway 4 Approach	2,500 FT	1,000 FT	1,750 FT
Runway 22 Approach	1,700 FT	1,000 FT	1,510 FT
Runway 12L Approach	2,500 FT	1,000 FT	1,750 FT
Runway 30R Approach	1,700 FT	1,000 FT	1,510 FT
Runway 12R Approach	2,500 FT	1,000 FT	1,750 FT
Runway 30L Approach	2,500 FT	1,000 FT	1,750 FT
Runway 17 Approach	1,700 FT	500 FT	1,010 FT
Runway 35 Approach	2,500 FT	1,000 FT	1,750 FT
Runway 4 Departure	1,700 FT	500 FT	1,010 FT
Runway 22 Departure	1,700 FT	500 FT	1,010 FT
Runway 12L Departure	1,700 FT	500 FT	1,010 FT
Runway 30R Departure	1,700 FT	500 FT	1,010 FT
Runway 12R Departure	1,700 FT	500 FT	1,010 FT
Runway 30L Departure	1,700 FT	500 FT	1,010 FT
Runway 17 Departure	1,700 FT	500 FT	1,010 FT
Runway 35 Departure	1,700 FT	500 FT	1,010 FT

SOURCE: HNTB Corporation, November 2022 (analysis).

The approach RPZ begins at a point 200 feet from the runway threshold. The departure RPZ begins 200 feet beyond the runway, unless declared distances are used. If the end of the takeoff run available (TORA) is not in the same location as the runway end, the departure RPZ begins 200 feet beyond the end of the TORA. The TORA of all runways at MSP equals the runway lengths; therefore, all departure RPZs begin 200 feet beyond the end of the runways.

The FAA memorandum *Interim Guidance on Land Uses Within a Runway Protection Zone* (September 27, 2012), found in Appendix I of FAA AC 150/5300-13B, *Airport Design* (March 31, 2022), establishes guidance for airport sponsors on introducing new incompatible land uses and activities within the RPZ:

- Buildings and structures
- Recreational land use
- Transportation facilities (i.e., railroads, public roads, vehicular parking)
- Fuel storage facilities
- Hazardous material storage
- Wastewater treatment facilities
- Above-ground utility installation (including any type of solar panel installations)

Based on this list of non-compatible uses, the RPZs at MSP were evaluated for potential incompatible land uses; the results are shown in **Table 3-44**.

Table 3-44: Runway Protection Zone Incompatible Land Uses

Exhibit 3-10 Index Number	RPZ	Incompatible Land Uses
36	RWY 4 Approach RPZ	Fuel Station, Portion of Sun Country Airlines Apron
37	RWY 22 Approach RPZ	Army Reserve Parking/Apron, Military Highway, Private Parcels
38	RWY 12L Approach RPZ	Route 62, E 58th St.; Bossen Field Park, S 31st St.
39	RWY 30R Approach RPZ	Minnesota State Highway 5, Snelling Lake
	RWY 12R Approach RPZ	None
40	RWY 30L Approach RPZ	Minnesota State Highway 5, Minnesota River, State Park Building
	RWY 17 Approach RPZ	None
41	RWY 35 Approach RPZ	Airport Lane, Interstate 494, 24th Ave., American Blvd., Portion of Fairfield Inn Parcel, Airport Lane
42	RWY 4 Departure RPZ	Army Reserve Parking Lots
	RWY 22 Departure RPZ	None
43	RWY 12L Departure RPZ	Minnesota State Highway 5, Snelling Lake
44	RWY 12R Departure RPZ	Minnesota State Highway 5, Snelling Lake Road
	RWY 30L Departure RPZ	None
45	RWY 17 Departure RPZ	Interstate 494, Airport Lane
46	RWY 4 Approach RPZ	Airport Fuel Station, Portion of Sun Country Airlines Apron

NOTES:
Exhibit Index Number refers to number labels in Exhibit 3-10
RPZ – Runway Protection Zone
SOURCE: HNTB Corporation, November 2022 (analysis).

Although the non-compatible land uses are within the RPZs, no mitigation is proposed as part of the LTP. The non-compatible land uses may remain unless new, non-aeronautical developments are proposed within the RPZ, runway minimums change, or there is a change to runway end points.

3.3.2.7 Parallel Runway Separation

Multiple runways that have parallel separation can greatly increase airfield capacity compared to single runway layouts. Depending on the type of aircraft operations (visual flight rules [VFR] versus instrument flight rules [IFR]) and the lateral separation between parallel runways, varying degrees of aircraft separation and dependencies can be achieved and greatly increase airfield capacity, particularly in instrument meteorological conditions at large airports with air carrier hub operations.

The standard for parallel runway separation for runways accommodating dual simultaneous straight-in instrument approaches is 3,200 feet. However, for parallel separations less than 3,600 feet, such as at MSP, additional ATC requirements need to be considered, including dependencies of the simultaneous approaches, radar separations, radar capabilities, and aircraft equipment. For these reasons, simultaneous approaches are not conducted at MSP. For IFR departures or mixed operations, the standard separation is at least 2,500 feet. At MSP, the lateral distance between parallel runways is 3,380 feet, which exceeds the standards for arrivals and departures. No deficiencies were noted at the airport.

3.3.2.8 Hold Lines

Hold lines prevent aircraft from entering protected areas of a runway or navigational surface and are also used to control aircraft traffic at taxiway intersections. There are three patterns of hold lines: Pattern A, Pattern B, and Pattern C.

Pattern A

Pattern A hold lines are characterized by two solid lines adjacent to two dashed lines. Pattern A hold lines are commonly referred to as runway hold lines and are used to instruct aircraft to stop prior to entering or crossing a runway while taxiing on a taxiway or intersecting runway, or in land and hold short operations (LAHSO), which are used to instruct an aircraft to stop prior to crossing an intersecting runway or taxiway after landing (such as on Runway 30L at Taxiway A8 / W8 and on Runway 22 at Taxiway S). Pattern A locations for LAHSO are dependent on local air traffic procedures and the design criteria of the intersecting runway or taxiway. Pattern A locations for all other use are based on the critical design aircraft and adjustments based on the elevation of the Airport above sea level.

Runways 4, 12L, 12R, 30L, and 35 have an RDC of D-V with visibility minimums lower than 3/4 mile. The standard Pattern A hold position for these runways is 288 feet from the runway centerline, which is determined by a minimum of 280 feet from the runway centerline plus 1 additional foot for every 100 feet of the Airport's elevation above sea level. Runways 22, 30R, and 17 have an RDC of D-V with visibility minimums not lower than 3/4 mile. The standard Pattern A hold position for these runways is 258 feet from the runway centerline, which is determined by a minimum of 250 feet from the runway centerline plus 1 additional foot for every 100 feet of the Airport's elevation above sea level.

Table 3-45 summarizes the Airport's existing Pattern A runway hold line separation deficiencies.

Table 3-45: Pattern A Runway Hold Line Separation

Exhibit 3-10 Index Number	Runway	Associated Taxiway/Runway	Standard Separation[1]	Separation Deficiency
19	RWY 4-22	P (west)	288 FT	7 FT
19		A (west)		5 FT
19		H (east)		2 FT
19		RWY 12R		5 FT
21	RWY 12R-30L	M (south)	288 FT	2 FT
21		RWY 4		2 FT
21		RWY 22		2 FT
21		A4		1 FT
20	RWY 12L-30R	G (north)	288 FT	7 FT
20		P4 (east)		1 FT

NOTE:
Exhibit Index Number refers to number labels in Exhibit 3-10
1 The standard separation increased to account for airport elevation per the FAA, AC 150/5300 13B, Table G-11, Footnote 8.
SOURCE: HNTB Corporation, November 2022 (analysis).

The LTP does not propose immediate mitigation to address Pattern A deficiencies. The locations of the runway hold lines represent an existing condition with no known aircraft conflicts or incursions resulting from their locations. The next time the applicable taxiway is reconstructed, the locations of the runway hold lines should be reviewed and adjustments should be made.

Pattern B

Pattern B hold lines are characterized by two transverse solid markings with short solid lines connecting the two transverse lines, creating a ladder effect. Pattern B hold lines are used to instruct aircraft to stop and hold short before entering a protected area of the Instrument Landing System (ILS) or the POFZ. **Table 3-46** lists the locations of the Pattern B markings. No deficiencies of Pattern B hold line locations were identified.

Table 3-46: Pattern B Hold Line Locations

Location	Feature
Taxiway W / Taxiway W9 / Taxiway W10 / Taxiway Y	Runway 12R Glideslope
Taxiway W / Taxiway W2	Runway 30L Glideslope
Taxiway R / USAF Apron	Runway 12L Glideslope

NOTE:
USAF – U.S. Air Force
SOURCE: HNTB Corporation, November 2022 (analysis).

Pattern C

Pattern C markings are characterized by transverse dashed lines and are commonly referred to as intermediate hold lines. Pattern C markings are used at taxiway/taxiway intersections or other locations as needed for operational purposes on taxiways to hold aircraft while taxiing. **Table 3-47** lists the locations of Pattern C markings at MSP. Locations near taxiway/taxiway intersections were reviewed while considering the designations of the intersecting taxiways. Deficiencies are noted in the table.

Table 3-47: Pattern C Hold Line Analysis

Taxiway	Location	Deficiency
Taxiway L	North of Taxiway N	0
Taxiway L	South of Taxiway L9	0
Taxiway K	South of Taxiway Y	0[1]
Taxiway S	East of Taxiway K	0
Taxiway Y	West of Taxiway T	22 FT
Taxiway Y	South of Taxiway W	0
Taxiway W	East of Taxiway Y	50 FT[2]
Taxiway C	East of Taxiway C1	25 FT
Taxiway M	East of Taxiway M2	0
Taxiway C	South of Taxiway W	0
Taxiway M	South of Taxiway W	0
Taxiway W	West of Taxiway C	0
Taxiway W	West of Taxiway W7	0
Taxiway W	West of Taxiway W6	0
Taxiway W	West of Taxiway W3	0
Taxiway A	East of Taxiway A4	0
Taxiway A	West of Taxiway A4	0
Taxiway B (2)	North of Taxiway A	0
Taxiway A	East of Taxiway A7	0
Taxiway A	West of Taxiway A7	0
Taxiway B	West of Tunnel	0
Taxiway A	West of Taxiway M	0
Taxiway D	North of Taxiway B	0
Taxiway M	North of Taxiway B	0
Taxiway D	North of Taxiway C6	0
Taxiway M	North of Taxiway C6	26 FT
Taxiway P	West of Taxiway G	0
Taxiway P	West of Taxiway P4	0
Taxiway Q	West of Concourse Taxilane	0
Taxiway P	East of Taxiway P3	0

NOTES:
ADG – Airplane Design Group
1 This was reviewed per the western de-ice position that accommodates a B757-300W (ADG IV).
2 This was reviewed per the ADG V taxiing on Taxiway Y. The spacing is 31 feet deficient for ADV IV.
SOURCE: HNTB Corporation, November 2022 (analysis).

The LTP does not propose immediate mitigation to address the Pattern C deficiencies, as they represent an existing condition with no known aircraft conflicts resulting from the location of the hold lines. The next time the applicable taxiway is reconstructed, the locations of the intermediate hold lines should be reviewed, and adjustments should be made.

Movement Area Boundary Line

The movement area boundary line is characterized by a single solid line adjacent to a dashed line. The movement area boundary line is used to delineate portions of the airfield that are under control by the Airport Traffic Control Tower (ATCT). Movement area boundary lines are present along apron areas adjacent to taxiways, surrounding deice pads, and on Taxiways C and S north of the Humphrey Remote Apron, identified as Apron G in Chapter 1. Along aprons and deice pads, the movement area boundary line coincides with the TOFA of the adjacent taxiway. There are no deficiencies noted regarding the locations of movement area boundary lines at MSP.

3.3.2.9 Runway-to-Taxiway Separation

Runway-to-taxiway separation is the distance between a runway centerline and the centerline of a parallel taxiway. Standard separations are set to ensure simultaneous runway and taxiway traffic can operate safely with negligible risk of wingtip clipping.

As introduced in **Section 3.1.1**, standard runway-to-taxiway separations are dependent on a runway's RDC and APRC. The APRC is dependent on the visibility minimums of the runway and sets separation standards as it relates to operating conditions without restrictions. This means that different separation standards can apply based on the type of aircraft on approach and the weather conditions at the time of the approach. **Table 3-48** presents the required runway-to-taxiway separations at MSP.

Table 3-48: Runway-to-Taxiway Separation

Runway	AAC-ADG	APRC	DPRC	Parallel Taxiway	Visibility Minimums	Standard	Deficiency
4	D-V	D/IV/2400 D/V/2400	D/IV, D/V	Taxiway C Taxiway M	Lower than 3/4 mile but not lower than 1/2 mile	400 FT	0 FT
22	D-V	D/IV/4000 D/V/4000	D/IV, D/V	Taxiway C Taxiway M	Lower than 1 mile but not lower than 3/4 mile	400 FT	0 FT
12L	D-V	D/IV/1200	D/IV, D/V	Taxiway P Taxiway R	Lower than 1/4 mile	500 FT	100 FT[1]
30R	D-V	D/IV/4000 D/V/4000	D/IV, D/V	Taxiway P Taxiway R	Lower than 1 mile but not lower than 3/4 mile	400 FT	0 FT
12R	D-V	D/IV/1200	D/IV, D/V	Taxiway A Taxiway W	Lower than 1/4 mile	500 FT	100 FT[1]
30L	D-V	D/IV/1200	D/IV, D/V	Taxiway A Taxiway W	Lower than 1/4 mile	500 FT	100 FT[1]
17	D-V	D/IV/4000 D/V/4000	D/IV, D/V	Taxiway K Taxiway L	Not lower than 1 mile	400 FT	0 FT
35	D-V	D/IV/1200	D/IV, D/V	Taxiway K Taxiway L	Lower than 3/4 mile	500 FT	100 FT[1]

NOTES:
AAC – Aircraft Approach Category; ADG – Airplane Design Group; APRC – Approach Reference Code; DPRC – Departure Reference Code
1 The runway-to-taxiway separation meets the standards except when it is less than Category I visibility minimums with ADG V aircraft on the approach.
SOURCE: HNTB Corporation, November 2022 (analysis).

All runways at MSP have parallel taxiways with centerlines that are at least 400 feet from the runway centerlines, which meets basic FAA AC 150/5300-13B separation criteria based on the RDC. With respect to APRC, as noted in **Table 3-48**, during conditions of visibility lower than 0.5 miles while a D-V aircraft is on approach to the specified runway, the runway-to-taxiway separation is deficient by 100 feet. When those two criteria are in effect, operational restrictions are placed on taxiways by the local ATCT. The LTP does not propose to increase any runway-to-taxiway separations since the existing deficiencies are operationally mitigated when necessary.

3.3.3 Runway Length Requirements

An airport's runway(s) should be long enough to accommodate arrivals and departures for the critical design aircraft. Runway length requirements for MSP were analyzed according to the guidance contained in FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design*. The AC describes three methods for determining runway length requirements based on the weight of aircraft expected to use the runway. The three categories are as follows:

- Aircraft with a maximum takeoff weight (MTOW) of 12,500 pounds or less
- Aircraft within an MTOW greater than 12,500 pounds up to and including 60,000 pounds
- Regional jets and aircraft with an MTOW greater than 60,000 pounds

MSP routinely has high volumes of operations by aircraft with an MTOW greater than 60,000 pounds. Therefore, the third methodology was used for determining the required runway length at MSP.

The fleet mix used for the TESM analysis described in **Section 3.4.5** was used in reviewing runway length requirements, which represents the 10 most demanding aircraft expected to operate at MSP. All aircraft in the selected fleet mix have an MTOW greater than 60,000 pounds. Per Chapter 4 of FAA AC 150/5300-13B, the approach identified for aircraft with an MTOW greater than 60,000 pounds requires reviewing the aircraft manufacturers' aircraft performance manuals to determine the optimal runway length requirements based on how the aircraft operates at the Airport. **Table 3-49** shows the fleet mix analyzed.

Table 3-49: Runway Length Fleet Mix

Aircraft	MTOW[1]
A350-900	590,839 LBS
MD-11	602,500 LBS
B747-400ER	910,000 LBS
B747-800	978,000 LBS
B787-10	560,000 LBS
B777F	766,800 LBS
A330-900	533,519 LBS
B767-300	350,000 LBS
B757-300	270,000 LBS
B737-900	174,200 LBS

NOTES:
MTOW – Maximum Takeoff Weight; LBS – Pounds
1 MTOW varies by the specific aircraft configuration and type of engines. The MTOWs shown are from aircraft performance manuals; they represent the MTOW used in the runway length analysis calculations.
SOURCE: HNTB Corporation, November 2022 (analysis).

Runway length requirements are dependent on several variables, including aircraft type and flap settings, MTOW, runway elevation, runway gradient, and weather conditions (surface condition, air temperature, and wind). **Table 3-50** and **Table 3-51** present the general Airport and runway characteristics affecting runway length requirements.

Table 3-50: Airport Meteorological Characteristics

Characteristic	Value
Elevation (Feet)	841.8
Mean Maximum Temperature Hottest Month (℉)	85 (July)

SOURCE: HNTB Corporation, November 2022 (analysis).

Table 3-51: Runway Gradient Characteristics

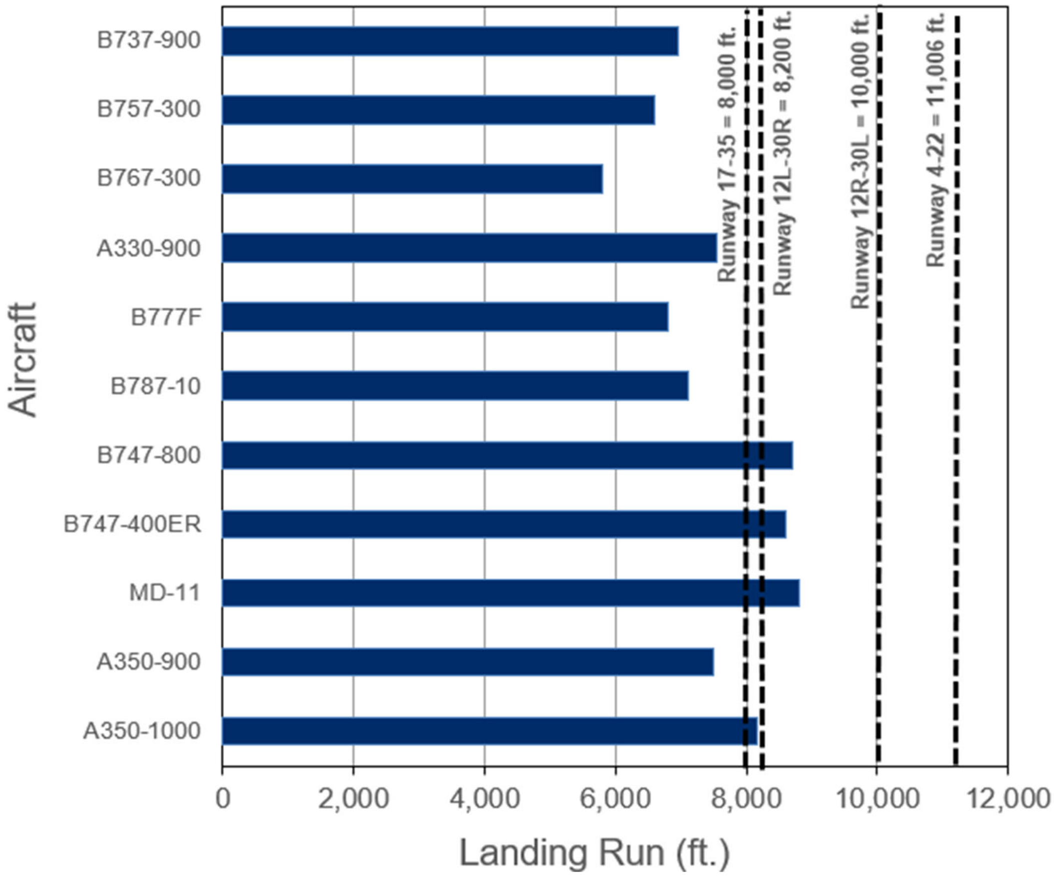
	4-22	12L-30R	12R-30L	17-35
Length (Feet)	11,006	8,200	10,000	8,000
Runway End Elevations (Feet)	833.5 / 830.3	838.6 / 819.5	841.8 / 814.4	840.4 / 833.3
Runway Effective Gradient	0.03%	0.23%	0.27%	0.09%
Grade Difference Between Runway Ends (Feet)	3	19	27	7

SOURCE: HNTB Corporation, November 2022 (analysis).

3.3.3.1 Landing Length Requirements

Exhibit 3-8 shows the landing length requirements of the fleet mix. The required landing lengths were obtained from the manufacturers' aircraft performance manuals and based on the maximum design landing weight and highest flap settings. When available, the “wet runway” condition was used to determine the landing length required. If no “wet runway” condition was included or published in a particular aircraft performance manual, then the base length obtained was increased by 15%, per guidance in AC 150/5300-13B.

Exhibit 3-8: Runway Length Requirements - Arrivals



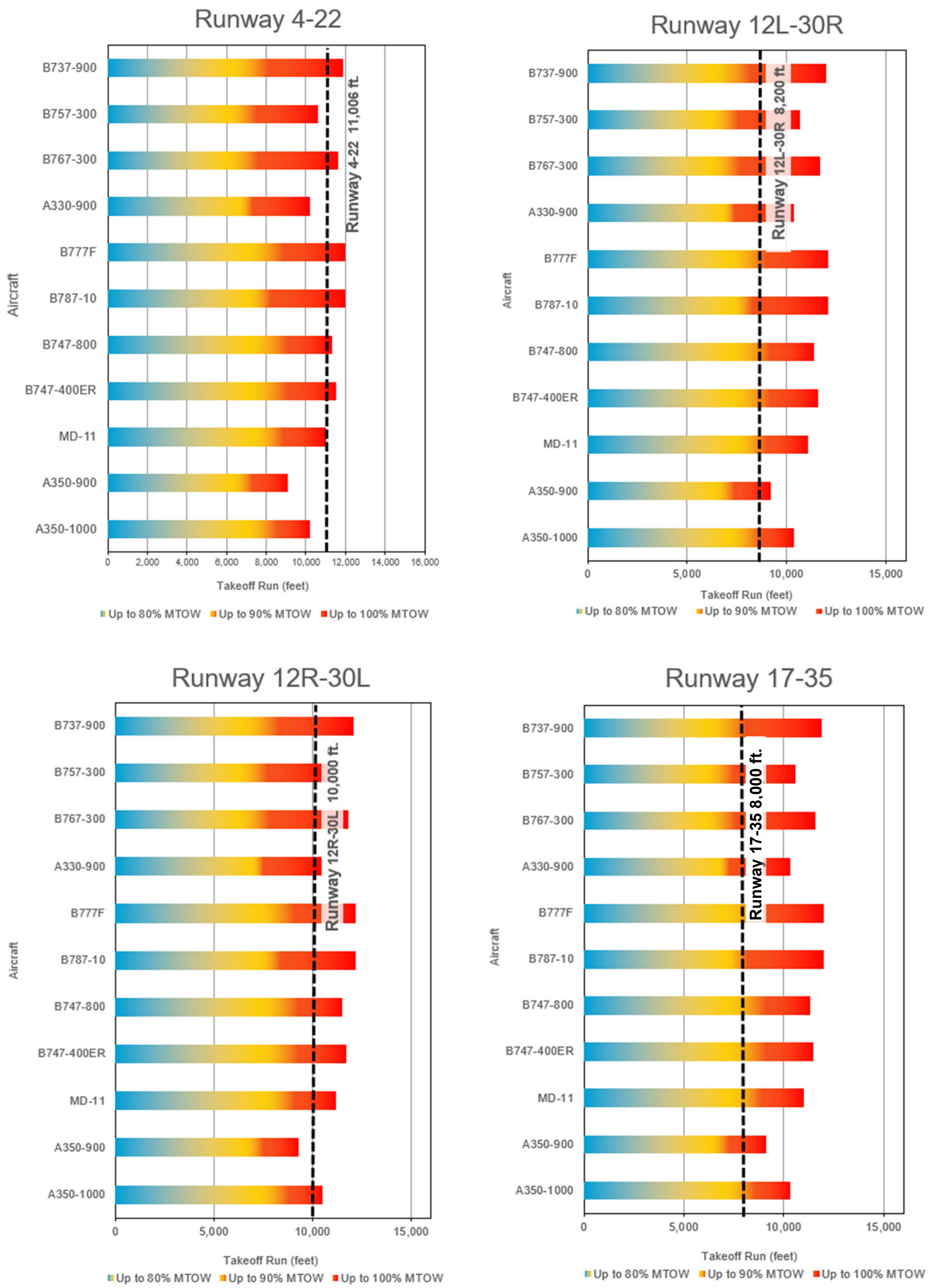
SOURCE: HNTB Corporation, November 2022 (analysis).

Based on the findings shown on **Exhibit 3-8**, MSP has sufficient runway length available to accommodate the landing length requirements of the selected fleet mix at maximum design landing weight. The two shortest runways at MSP, Runway 17-35 and Runway 12L-30L, fall short of the maximum requirements for the 747-400, 747-800, MD-11, and A350-1000. However, it should be noted that (a) other runways at MSP provide the requisite landing length for these aircraft, and (b) this analysis represented a maximum design condition; in normal circumstances, aircraft do not typically land at maximum design landing weights.

3.3.3.2 Takeoff Runway Length Requirements

Exhibit 3-9 shows the takeoff runway length requirements for the selected fleet mix with the existing lengths of Runway 4-22 (11,006 feet), Runway 12L-30R (8,200 feet), Runway 12L-30R (10,000 feet), and Runway 17-35 (8,000 feet) superimposed on the chart for reference. Each aircraft's takeoff runway length requirements are shown based on the following values: up to 80% MTOW (green), up to 90% MTOW (yellow), and up to 100% MTOW (red). This analysis indicates that the existing runway lengths at MSP require most of the critical design fleet mix to reduce fuel or payload to reduce the allowable takeoff weight from MTOW, based on the existing runway lengths.

Exhibit 3-9: Runway Length Requirements - Departures



NOTE:
MTOW – Maximum Takeoff Weight
SOURCE: HNTB Corporation, November 2022 (analysis).

It is important to note that this analysis was completed as a planning-level exercise and does not conclude that a longer runway is needed to accommodate the fleet mix, i.e., the most demanding aircraft with greater than 500 operations per year at MSP, or that the existing runway length limits the size of aircraft operating at the Airport. As previously noted, aircraft may need to adjust their takeoff weight to depart a particular runway. Prior to each flight, the flight crew and/or airline dispatch is responsible to determine the actual payload and acceptable runway length for the flight based on the aircraft operating characteristics, airline operating procedures, weather conditions at the Airport, distance of the flight, available takeoff and landing runway lengths, and a myriad of other factors. Based on forecast operations and the critical design aircraft through the 2040 LTP horizon, additional runway length at MSP is not required.

3.3.4 Taxiway/Taxilane Geometric Standards

The following subsections describe the requirements related to taxiway and taxilane design standards. The requirements are also compared against existing conditions to identify deficiencies and/or shortfalls.

3.3.4.1 Taxiway Design Group

TDG is a principle that groups aircraft based on landing gear dimensions. The TDG relates the dimensions of the cockpit to main gear and the width of the main landing gear of aircraft, which are primary design factors for taxiway and taxilane width and fillet standards. Based on this principle, different areas of an airport may have taxiways or taxilanes with different TDG classifications, depending on the location of various aircraft operations and aircraft sizes. Most taxiways at MSP are TDG 5, with a few taxiways classified as either TDG 3 or TDG 4. **Table 3-52** describes the taxiways at MSP.

The future critical design aircraft, the A350-1000, is a TDG 6 aircraft. Implications to various taxiway components associated with this change are discussed in the following sections.

3.3.4.2 Taxiway/Taxilane Width and Shoulder Width

Required taxiway width and shoulder width is a function of TDG. The existing taxiway system at MSP was reviewed for the width of each taxiway and associated shoulder and compared to the required standard width. **Table 3-52** shows the results of this review. Based on the results, there are no deficiencies in taxiway width and shoulder width at MSP.

The future up gauge in critical design aircraft from TDG 5 to TDG 6 will not affect the analysis of the taxiway width and shoulder width. The standard taxiway and shoulder widths for TDG 6 aircraft are the same as for TDG 5 aircraft. TDG 6 aircraft are expected to operate on the same taxiways currently designated as TDG 5 taxiways. TDG 6 aircraft are expected to operate primarily on taxiways supporting Runway 12R-30L and Runway 4-22. However, modifications may be required at taxiway-taxiway or taxiway-runway intersections in these areas for necessary fillet improvements. These improvements are recommended at the time of pavement reconstruction.

Table 3-52: (1 of 5) Taxiway/Taxilane Width

Taxiway	Type	Existing Width	Existing Shoulder Width	TDG	Standard Width	Standard Shoulder Width	Deficiency (Width/Shoulder)
A	Full Parallel	75 FT	35 FT	5	75 FT	30 FT	None/None
A1	RWY Entrance / Crossover	100 FT	35 FT	5	75 FT	30 FT	None/None
A2	RWY Entrance / Crossover	100 FT	35 FT	5	75 FT	30 FT	None/None
A3	High-Speed Exit / Crossover	100 FT	35 FT	5	75 FT	30 FT	None/None
A4	High-Speed Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
A5	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
A7	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
A8	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
A9	RWY Entrance / Crossover	100 FT	35 FT	5	75 FT	30 FT	None/None
A10	RWY Entrance / Crossover	100 FT	35 FT	5	75 FT	30 FT	None/None
B	Partial Parallel	75 FT	35 FT	5	75 FT	30 FT	None/None
B8	Crossover	88 FT	30 FT	5	75 FT	30 FT	None/None
C	Full Parallel	75 FT	34 FT	5	75 FT	30 FT	None/None
C1	Crossover	100 FT	30 FT	5	75 FT	30 FT	None/None
C2	Crossover / Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
C5	Crossover	100 FT	35 FT	5	75 FT	30 FT	None/None
C6	Crossover / Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
C9	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
C10	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
D	Partial Parallel	75 FT	30 – 35 FT	5	75 FT	30 FT	None/None
F	Future Partial Parallel	75 FT[1]	30 FT[1]	5	75 FT	30 FT	None/None

NOTES:
TDG – Taxiway Design Group
1 The assumed standard dimensions will be designed and constructed based on the preliminary edge of pavement provided by TKDA.
2 The taxilane will be removed as part of the LTP's preferred concept.
3 Formal shoulders are not striped; however, the total pavement width exceeds the total required width of the taxilane width, plus shoulders, for the applicable TDG standards noted for the taxilanes.
4 Runway 4-22 is periodically used as a taxiway and has taxiway edge lights installed for these occurrences. The LTP does not propose any changes to the occasional use of Runway 4-22 as a taxiway.
SOURCE: HNTB Corporation, November 2022 (analysis).

Table 3-52: (2 of 5) Taxiway/Taxilane Width

Taxiway	Type	Existing Width	Existing Shoulder Width	TDG	Standard Width	Standard Shoulder Width	Deficiency (Width/Shoulder)
F1	Future RWY Entrance	75 FT[1]	30 FT[1]	5	75 FT	30 FT	None/None
F2	Future RWY Entrance	75 FT[1]	30 FT[1]	5	75 FT	30 FT	None/None
F3	Future Crossover	75 FT[1]	30 FT[1]	5	75 FT	30 FT	None/None
F4	Future Crossover	75 FT[1]	30 FT[1]	5	75 FT	30 FT	None/None
G	Midfield Connector / Exit	75 FT	35 FT	5	75 FT	30 FT	None/None
G1	Crossover	75 FT	50 FT	5	75 FT	30 FT	None/None
G2	Crossover	75 FT	35 FT	5	75 FT	30 FT	None/None
H	Midfield Connector / Exit	75 FT	35 FT	5	75 FT	30 FT	None/None
J	Midfield Connector	50 FT	25 FT	5	75 FT	30 FT	None/None
K	Full Parallel	75 FT	35 FT	5	75 FT	30 FT	None/None
K1	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
K2	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
K3	Exit	100 FT	34 FT	5	75 FT	30 FT	None/None
K6	High-Speed Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
K8	High-Speed Exit / Crossover	75 – 100 FT	35 – 36 FT	5	75 FT	30 FT	None/None
K10	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
L	Full Parallel	75 FT	35 FT	5	75 FT	30 FT	None/None
L3	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
L5	Apron	75 FT	35 FT	5	75 FT	30 FT	None/None
L5	Apron Taxilane	75 FT	35 FT	5	75 FT	30 FT	None/None
L6	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
L6	Apron Taxilane	100 FT	35 FT	5	75 FT	30 FT	None/None
L7	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None

NOTES:
TDG – Taxiway Design Group
1 The assumed standard dimensions will be designed and constructed based on the preliminary edge of pavement provided by TKDA.
2 The taxilane will be removed as part of the LTP-preferred concept.
3 Formal shoulders are not striped; however, the total pavement width exceeds the total required width of the taxilane width, plus shoulders, for the applicable TDG standards noted for the taxilanes.
4 Runway 4-22 is periodically used as a taxiway and has taxiway edge lights installed for these occurrences. The LTP does not propose any changes to the occasional use of Runway 4-22 as a taxiway.
SOURCE: HNTB Corporation, November 2022 (analysis).

Table 3-52: (3 of 5) Taxiway/Taxilane Width

Taxiway	Type	Existing Width	Existing Shoulder Width	TDG	Standard Width	Standard Shoulder Width	Deficiency (Width/Shoulder)
L9	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
L10	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
M	Partial Parallel / Exit	75 FT	35 FT	5	75 FT	30 FT	None/None
M2	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
M6	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
N	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
P	Full Parallel	75 FT	35 FT	5	75 FT	30 FT	None/None
P1	RWY Entrance	100 FT	34 FT	5	75 FT	30 FT	None/None
P2	RWY Entrance	100 FT	34 FT	5	75 FT	30 FT	None/None
P3	High-Speed Exit	75 FT	34 FT	5	75 FT	30 FT	None/None
P4	High-Speed Exit	75 FT	35 FT	5	75 FT	30 FT	None/None
P8	High-Speed Exit	75 FT	34 FT	5	75 FT	30 FT	None/None
P9	RWY Entrance	100 FT	34 FT	5	75 FT	30 FT	None/None
P10	RWY Entrance	100 FT	34 FT	5	75 FT	30 FT	None/None
Q	Partial Parallel Taxilane	50 FT	34 FT	3	50	20 FT	None/None
		55 FT	34 FT	4	50	20 FT	None/None
		100 FT	34 FT	5	50	30 FT	None/None
		75 FT	34 FT	4	50	20 FT	None/None
		75 FT	34 FT	4	50	20 FT	None/None
R	Partial Parallel / Midfield Connector	75 FT	30 – 34 FT	5	75 FT	30 FT	None/None
R3	Crossover	75 FT	33 FT	5	75 FT	30 FT	None/None
R4	Crossover	60 FT	30 FT	5	75 FT	30 FT	None/None
R5	Crossover	75 FT	30 FT	5	75 FT	30 FT	None/None
R6	Crossover	80 FT	30 FT	5	75 FT	30 FT	None/None
R7	Crossover	82 FT	30 FT	5	75 FT	30 FT	None/None
R8	Crossover	125 FT	9 FT	5	75 FT	30 FT	None/None

NOTES:
TDG – Taxiway Design Group
1 The assumed standard dimensions will be designed and constructed based on the preliminary edge of pavement provided by TKDA.
2 The taxilane will be removed as part of the LTP-preferred concept.
3 Formal shoulders are not striped; however, the total pavement width exceeds the total required width of the taxilane width, plus shoulders, for the applicable TDG standards noted for the taxilanes.
4 Runway 4-22 is periodically used as a taxiway and has taxiway edge lights installed for these occurrences. The LTP does not propose any changes to the occasional use of Runway 4-22 as a taxiway.
SOURCE: HNTB Corporation, November 2022 (analysis).

Table 3-52: (4 of 5) Taxiway/Taxilane Width

Taxiway	Type	Existing Width	Existing Shoulder Width	TDG	Standard Width	Standard Shoulder Width	Deficiency (Width/Shoulder)
R9	RWY Entrance	100 FT	34 FT	5	75 FT	30 FT	None/None
R10	RWY Entrance	100 FT	34 FT	5	75 FT	30 FT	None/None
S	Midfield Connector / RWY Entrance / Crossover	75 FT	35 FT	5	75 FT	30 FT	None/None
S1	Apron Taxilane	100 FT	30 FT / 35 FT	5	75 FT	30 FT	None / None
S2	Apron Access Taxilane	75 FT	0 FT	5	75 FT	30 FT	None / 30 FT[2]
S3	Apron Taxilane	100 FT	30 FT	3	50 FT	20 FT	None / None
S4	Apron Taxilane	100 FT	30 FT	4	50 FT	20 FT	None / None
T	Midfield Connector / Exit / Crossover	75 FT	35 FT	4	50 FT	20 FT	None/None
		100 FT	35 FT	5	75 FT	30 FT	None/None
W	Full Parallel	75 FT	35 FT	5	75 FT	30 FT	None/None
W1	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
W2	RWY Entrance	100 FT	34 FT	5	75 FT	30 FT	None/None
W3	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
W5	Exit / Crossover	100 FT	35 FT	5	75 FT	30 FT	None/None
		75 FT	35 FT	4	50 FT	20 FT	None/None
W5	Apron Access Taxilane	75 FT	35 FT	4	50 FT	20 FT	None/None
W6	Crossover	50 FT	20 FT	4	50 FT	20 FT	None/None
W6	Apron Access Taxilane	50 FT	20 FT	3	50 FT	20 FT	None/None
W7	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None
W8	Exit	100 FT	35 FT	5	75 FT	30 FT	None/None

NOTES:
TDG – Taxiway Design Group
1 The assumed standard dimensions will be designed and constructed based on the preliminary edge of pavement provided by TKDA.
2 The taxilane will be removed as part of the LTP-preferred concept.
3 Formal shoulders are not striped; however, the total pavement width exceeds the total required width of the taxilane width, plus shoulders, for the applicable TDG standards noted for the taxilanes.
4 Runway 4-22 is periodically used as a taxiway and has taxiway edge lights installed for these occurrences. The LTP does not propose any changes to the occasional use of Runway 4-22 as a taxiway.
SOURCE: HNTB Corporation, November 2022 (analysis).

Table 3-52: (5 of 5) Taxiway/Taxilane Width

Taxiway	Type	Existing Width	Existing Shoulder Width	TDG	Standard Width	Standard Shoulder Width	Deficiency (Width/Shoulder)
W9	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
W10	RWY Entrance	100 FT	35 FT	5	75 FT	30 FT	None/None
Y	High-Speed Exit / Midfield Connector	75 – 100 FT	35 FT	5	75 FT	30 FT	None/None
Z	Crossover	75 FT	35 FT	5	75 FT	30 FT	None/None
Conc. A/B	Apron Taxilane	35 FT	0 FT[3]	2	35 FT	15 FT	None/None[3]
Conc. E/F	Apron Taxilane	160 – 180 FT	0 FT[3]	3-Apr	50 FT	20 FT	None/None[3]
RWY 4-22	Runway[4]	150 FT	35 FT	6	75 FT	30 FT	None / None

NOTES:
TDG – Taxiway Design Group
1 The assumed standard dimensions will be designed and constructed based on the preliminary edge of pavement provided by TKDA.
2 The taxilane will be removed as part of the LTP-preferred concept.
3 Formal shoulders are not striped; however, the total pavement width exceeds the total required width of the taxilane width, plus shoulders, for the applicable TDG standards noted for the taxilanes.
4 Runway 4-22 is periodically used as a taxiway and has taxiway edge lights installed for these occurrences. The LTP does not propose any changes to the occasional use of Runway 4-22 as a taxiway.
SOURCE: HNTB Corporation, November 2022 (analysis).

3.3.4.3 Taxiway-to-Taxiway Separation

Taxiway-to-taxiway separation is the distance between a taxiway centerline and the centerline of a parallel taxiway. Standard separations are set to ensure simultaneous parallel taxiing traffic can operate safely with adequate wingtip clearance. Standard taxiway-to-taxiway separations are based on the ADG for which the parallel taxiways have been designed. The standard separation is calculated as one-half of each taxiway's taxiway safety area width, plus the standard taxiway wingtip clearance for the larger ADG.

The standard taxiway-to-taxiway separation for parallel ADG V taxiway combinations at MSP is 249 feet. Based on a review of the ADG V parallel taxiway separation, deficiencies were identified at MSP, as listed in **Table 3-53**.

Table 3-53: Taxiway-to-Taxiway Separation

Parallel Taxiway Combination	Segment	Standard Separation	Existing Separation	Deficiency	Notes
Taxiway A – Taxiway B	A1 – A3	249 FT	237 FT	12'	Existing MOS in place (1999-AGL-1450-AGL), restricting Taxiway B to aircraft with wingspans less than 135 feet
Taxiway A – Taxiway B[1]	A3 – A4	249 FT	240 FT	9'	Existing MOS in place (MSP-2019-06734), restricting Taxiway B to ADG IV aircraft
Taxiway A – Taxiway B[2]	A4 – A7	249 FT	55 FT	194'	Aircraft currently restricted to using either Taxiway A or Taxiway B at this location
Taxiway A – Taxiway B[3]	A7 – D	249 FT	240 FT	9'	Existing MOS in place (MSP-2019-06734), restricting Taxiway B to ADG IV aircraft
Taxiway P – Taxiway Q	P1 – P3	249 FT	154 FT	95'	Existing MOS in place (2005-AGL-458-NRA) closes Taxiway Q if an aircraft larger than a B757-300WL is on Taxiway P
Taxiway P – Taxiway Q	P3 – D	249 FT	172 FT	77'	Existing MOSs in place (2015-AGL-8465-NRA through 2015-AGL-8467-NRA), restricting Taxiway Q to aircraft with wingspans less than 135 feet; permitting simultaneous taxiing of aircraft up to the B757-300WL; or permitting larger ADG IV aircraft on Taxiway P while restricting Taxiway Q to a CRJ-900 or smaller
Taxiway H – Taxiway J	M – Q	249 FT	210 FT	39'	Existing MOS in place (MSP-2018-04754), restricting Taxiway J to aircraft with wingspans less than 85.3 feet
Taxiway S – Humphrey Remote Apron	–	249 FT	235 FT	14'	Simultaneous taxiing operations currently restricted to aircraft no larger than the B777-200LR on Taxiway S, with the B767-300ER on the Humphrey Remote Apron taxilane

NOTES:
MOS – Modification of Standards; ADG – Airplane Design Group; VSR – Vehicle Service Road
1 The terminal concepts impact or remove this de-ice pad to varying degrees. Depending on the preferred terminal concept, the restriction can be removed if the deice pad is removed.
2 Concept improvement to extend the VSR tunnel and realign Taxiway B, which would enable this restriction to be revised. Taxiway B is restricted to ADG IV and B757 or smaller aircraft with ADG V on Taxiway A.
3 Concourse F and the adjacent VSR are proposed to be realigned in the current terminal concepts. The restriction can be removed in the current concepts; however, Taxiway B to the southeast is restricted to ADG IV.
SOURCE: HNTB Corporation, November 2022 (analysis).

Except as noted in the table, the LTP does not propose mitigation to remove the substandard taxiway-to-taxiway separations. It is anticipated that the existing Modification of Standards (MOS) will remain in place through the LTP horizon, since the Airport is geographically constrained and mitigating the substandard would require physically moving or removing sections of the taxiway, which would cause greater operational impacts than the restrictions currently in place. There are no known issues or concerns with the current operational restrictions in place for these taxiways.

3.3.4.4 Taxiway/Taxilane Safety Area

The taxiway safety area, which also applies to taxilanes, is an area symmetrical to the taxiway or taxilane centerline. Its purpose is to support the safe passage of aircraft and emergency vehicle equipment. Standard taxiway safety area widths are given by the wingspan of the largest aircraft belonging to the ADG for which the taxiway has been designed. The taxiway safety area must be kept clear of all objects, except for objects required to be within the surface due to their function.

The taxiway safety area also must be adequately graded to remove hazardous surface variations and prevent the accumulation of surface water.

The following dimensional standards apply for the taxiway safety area by ADG:

- Taxiways designed for ADG V aircraft have a standard taxiway safety area width of 214 feet (107.0 feet on either side of the taxiway centerline).
- Taxiways designed for ADG IV aircraft have a standard taxiway safety area width of 171 feet (85.5 feet on either side of the taxiway centerline).
- Taxiways designed for ADG III aircraft have a standard taxiway safety area width of 118 feet (59.0 feet on either side of the taxiway centerline).

Based on a review of the taxiway safety areas at MSP, there are two deficient areas, as noted in **Table 3-54**.

Table 3-54: Taxiway Safety Area Deficiencies

Exhibit 3-10 Index Number	Taxiway Safety Area	Deficiency	ADG	Object[1]
22	Taxiway W (W6 – W7)	14'	V	VSR Tunnel Portal

NOTES:
Exhibit Index Number refers to number labels in Exhibit 3-10
ADG – Airplane Design Group; VSR – Vehicle Service Road
1 Miscellaneous surveyed objects were not included in the inventory. It is assumed these are at-grade structures that do not penetrate the taxiway safety area.
SOURCE: HNTB Corporation, November 2022 (analysis).

The LTP does not propose any mitigation to this substandard condition; however, the MAC is seeking opportunities for mitigation in the future. During design development of the T2 north expansion and the deice pad / Remain Overnight (RON) area, there may also be an opportunity to remedy the substandard condition.

3.3.4.5 Taxiway Edge Safety Margin

The TESM is the distance between the outer edge of the landing gear of an aircraft with its nose on the centerline and the edge of the taxiway pavement. Its purpose is to protect from possible aircraft wander while taxiing, ensuring an aircraft's gear remains on taxiway-strength pavement. The TDG of a given taxiway sets the dimensional standards for the TESM. Taxiway fillets and straight segments should be designed so that all aircraft types using it do not exceed the TESM.

Taxiway fillets are designed for cockpit-over-centerline steering, meaning a pilot maneuvers a taxiing aircraft to keep the centerline beneath the cockpit during turning maneuvers. Prior to 2011, it was acceptable to design taxiway intersections for either cockpit-over-centerline steering or judgmental oversteer. Judgmental oversteer is a technique where pilots intentionally steer the cockpit outside the marked centerlines on turns. Change 17 to FAA AC 150/5300-13, issued in September 2011, removed judgmental oversteer as a design method for taxiway intersections due to the increased risk of aircraft excursions from the pavement and slower taxi speeds exhibited during the maneuver. Judgmental oversteer remains as an operational maneuver, but it is not acceptable as a design parameter. The TESM analysis conducted for the LTP used cockpit-over-centerline steering as a measurement, which is still the standard in FAA AC 150/5300-13B for taxiway intersection design.

Standard TESMs are dependent on an aircraft's TDG classification:

- For aircraft belonging to **TDG 5 or 6**, the standard TESM is 14.0 feet.
- For aircraft belonging to **TDG 3 or 4**, the standard TESM is 10.0 feet.
- For aircraft belonging to **TDG 2A or 2B**, the standard TESM is 7.5 feet.
- For aircraft belonging to **TDG 1A or 1B**, the standard TESM is 5.0 feet.

For a TESM analysis of the MSP airfield, 10 aircraft types were selected. These aircraft represented the most demanding aircraft in the present and projected fleet mix operating at MSP with regular use, including the legacy and future critical design aircraft. **Table 3-55** lists the TESM fleet mix.

The number of annual operations per aircraft was taken from the *MSP LTP Noise Contour Draft Technical Memorandum* (Noise Tech Memo), completed in February 2023. The 2040 baseline number of annual operations is listed in the table.

Table 3-55: Taxiway Edge Safety Margin Fleet Mix

Aircraft	2040 Annual Operations
Airbus A330-900 (A339)	4,015
Airbus A350-900 (A359)	365
Boeing 747-400 (B744)	<180[1]
Boeing 747-8 (B748)	365
Boeing 757-300 (B753)	11,680
Boeing 767-300 (B763)	4,015
Boeing 777 Freighter (B77F)	730
Boeing 787-10 (B78X)	<180[2]
McDonnel Douglas MD-11 (MD11)	1,460

NOTES:
1 The assumed number is based on the phasing out of the B747-400. It was included in the analysis due to its designation as the legacy critical design aircraft.
2 This represents less than 1 operation per day, per the Long-Term Plan Noise Contour Draft Technical Memorandum.
SOURCE: HNTB Corporation, November 2022 (analysis).

TESM compliance was checked for the 10 aircraft at all taxi maneuvers on the MSP airfield. **Table 3-56** summarizes the TESM analysis.

Table 3-56: Taxiway Edge Safety Margin Analysis

Criteria	Aircraft Type									
	A339	A359	A35K	B744	B748	B753	B763	B77F	B78X	MD11
ADG	V	V	V	V	VI	IV	IV	V	V	IV
TDG	5	5	6	5	5	4	5	6	6	6
CMG[1]	97.26 FT	99.27 FT	111.78 FT	91.67 FT	89.67 FT	85.33 FT	82.17 FT	94.88 FT	103.84 FT	101.74 FT
MGW[1]	41.37 FT	42.22 FT	42.13 FT	41.33 FT	41.75 FT	28.00 FT	35.75 FT	36.00 FT	39.04 FT	41.24 FT
Turning Maneuvers Examined	562	562	562	562	562	562	562	562	562	562
Feasible Turns[2]	518	519	505	521	520	546	547	520	518	544
Feasible Turns Violating TESM	484 (93.4%)	491 (94.6%)	484 (95.8%)	442 (84.8%)	489 (94.0%)	226 (41.4%)	374 (68.4%)	486 (93.5%)	487 (94.0%)	513 (94.3%)
Feasible Turns Violating TESM by >14 Feet[3]	238 (45.9%)	272 (52.4%)	370 (73.3%)	132 (25.3%)	264 (50.8%)	N/A	69 (12.6%)	224 (43.1%)	285 (55.0%)	302 (55.5%)
Feasible Turns Violating TESM by >10 Feet[3]	N/A	N/A	N/A	N/A	N/A	41 (7.5%)	N/A	N/A	N/A	N/A

NOTES:
ADG – Airplane Design Group; TDG – Taxiway Design Group; CMG – Cockpit to Main Gear; MGW – Main Gear Width (Outer to Outer); TESM – Taxiway Edge Safety Margin; N/A – Not Applicable
1 Dimensions were obtained from the FAA's AC Database, when available (some dimensions were "unverified") or AviPLAN software.
2 "Feasible turns" indicates that a centerline for the maneuver exists, that the centerline radius is adequate for the aircraft to perform a cockpit-over-centerline maneuver without oversteering, and that the pavement width on both the origin and destination segments is greater than or equal to the standard for the aircraft's TDG.
3 The standard TESMs for TDG 5/6 and 4 are 14 feet and 10 feet, respectively. A TESM violation greater than the standard TESM implies the aircraft landing gear must travel onto the shoulder to perform the maneuver, even assuming a perfect cockpit-over-centerline maneuver. This represents a safety concern, as taxiway shoulder pavement is designed to a lower strength than taxiway pavement.
SOURCE: HNTB Corporation, November 2022 (analysis).

The LTP does not propose targeted improvements to the taxiway geometry to address TESM deficiencies. While the existing taxiway edge geometry does not provide for the current TESM width based on the analysis, the existing intersections were designed to standard at the time of their construction. During the LTP process, airfield maintenance staff were contacted to inquire if taxiway edge lights were commonly repaired or replaced due to aircraft strikes, which could be a result of aircraft traversing outside the taxiway width due to substandard TESM width. The lack of taxiway edge light repairs would indicate that pilots of the larger aircraft analyzed use historical knowledge/experience and judgmental oversteer while navigating the taxiway system to remain within the taxiway limits. As taxiway pavements are rehabilitated, particularly those expected to serve TDG 6 aircraft, such as Taxiways A, B, W, and C, the edge geometry should be revised to meet current taxiway fillet geometry and TESM standards. The MAC will also continue to monitor aircraft movements and identify whether taxiway intersections should be prioritized for geometry changes based on the needs of the aircraft operating at the Airport.

3.3.4.6 Taxiway/Taxilane Object-Free Area

The TOFA and the TLOFA are areas symmetrical about the taxiway centerline and are wider than the taxiway safety area. Their purpose is to provide vertical and horizontal wingtip clearance for taxiing aircraft. Standard TOFA/TLOFA widths are determined by the wingspan plus the minimum taxiway/taxilane wingtip clearance of the largest aircraft belonging to the ADG for which the taxiway/taxilane has been designed. The TOFA/TLOFA must be kept clear of all objects, except for objects required to be within the TOFA/TLOFA due to their function. The TOFA/TLOFA also must be appropriately graded to provide drainage of water away from the taxiway safety area.

The following dimensional standards for the taxiway/taxilane apply by ADG:

- Taxiways/taxilanes designed for ADG V aircraft have a standard TOFA/TLOFA width of 285/270 feet (142.5/135.0 feet on either side of the taxiway/taxilane centerline).
- Taxiways/taxilanes designed for ADG IV aircraft have a standard TOFA/TLOFA width of 243/224 feet (121.5/112.0 feet on either side of the taxiway/taxilane centerline).
- Taxiways/taxilanes designed for ADG III aircraft have a standard TOFA/TLOFA width of 171/158 feet (85.5/79.0 feet on either side of the taxiway/taxilane centerline).

Based on a review of TOFAs and TLOFAs, deficiencies to standards in TOFAs were found at MSP, as shown in **Table 3-57**. There are no deficiencies in TLOFAs.

Table 3-57: Taxiway Object-Free Area Deficiencies

Exhibit 3-10 Index Number	TOFA Location	Deficiency	Description
23	Taxiway L3 near Runway 17-35	17.5 feet	A PAPI utility structure lies within the Taxiway L3 TOFA near the intersection with Runway 17-35.

NOTES:
Exhibit Index Number refers to number labels in Exhibit 3-10
TOFA – Taxiway Object-Free Area; PAPI – Precision Approach Path Indicator
SOURCE: HNTB Corporation, November 2022 (analysis).

A MOS is recommended to be pursued by the MAC for mitigation of the deficient object within the TOFA.

3.3.4.7 Navigational Aid Critical Areas

A NAVAID critical area is an area of ground near a NAVAID facility clear of obstructions. Its purpose is to prevent interference with the NAVAID signal. This section reviews the required standards and any existing gaps associated with the LOC critical area, GS critical area, and the Very High Frequency Omni-Directional Range (VOR) / Distance Measuring Equipment (DME).

Glideslope Critical Area

MSP has five critical areas associated with its five Glideslope (GS) antennas serving Runways 12L, 30R, 12R, 30L, and 35. These critical areas are on one side of the runway near the threshold and extend outward from the side of the runway pavement. The precise dimensions of the critical area depend on the type of equipment installed. **Table 3-58** lists the GS critical area deficiencies.

Table 3-58: Glideslope Critical Area Deficiencies

Exhibit 3-10 Index Number	Runway	Deficiency
24	12R	VSR penetration; current mitigation is signs on the VSR outside the critical area
25	30R	1 – Wind cone inside critical area 2 – Gravel road inside critical area
26	35	Wind cone inside critical area

NOTES:
Exhibit Index Number refers to number labels in Exhibit 3-10
VSR – Vehicle Service Road
SOURCE: HNTB Corporation, November 2022 (analysis).

The two wind cones should be re-sited and relocated outside the GS critical areas. Additional or new signage should be installed on the gravel road to warn vehicle operators that they are entering the GS critical area.

Localizer Critical Area

The dimensions and shape of a NAVAID critical area vary depending on the type of NAVAID. MSP has eight critical areas associated with its eight LOCs serving each runway approach. These critical areas are centered on the runway centerline, extend 50 feet behind the LOC and partway down the runway (with the length depending on the type of equipment installed), and are either 400 feet wide (Runways 4, 22, 30R, and 17) or 500 feet wide (Runways 12L, 12R, 30L, and 35). **Table 3-59** highlights the deficiencies found in the LOC critical areas.

Table 3-59: Localizer Critical Area Deficiencies

Exhibit 3-10 Index Number	Runway	Deficiency
27	12R	A pole is inside the Runway 12R localizer critical area.
28	12R	A gravel road is inside the Runway 12R localizer critical area. The road is the service road for the localizer, running behind the facility.
29	30R	Two poles are inside the Runway 30R localizer critical area.
30	12L	A gravel road is inside the Runway 12L localizer critical area. The road is the service road for the localizer, running behind the facility.
31	17	A pole is inside the critical area.

NOTE: Exhibit Index Number refers to number labels in Exhibit 3-10
SOURCE: HNTB Corporation, November 2022 (analysis).

The LTP does not propose any targeted mitigation for the identified objects within the LOC critical areas. The LOCs are continuously monitored and routinely checked, and the identified objects have not caused known interferences detrimental to the performance of the LOCs.

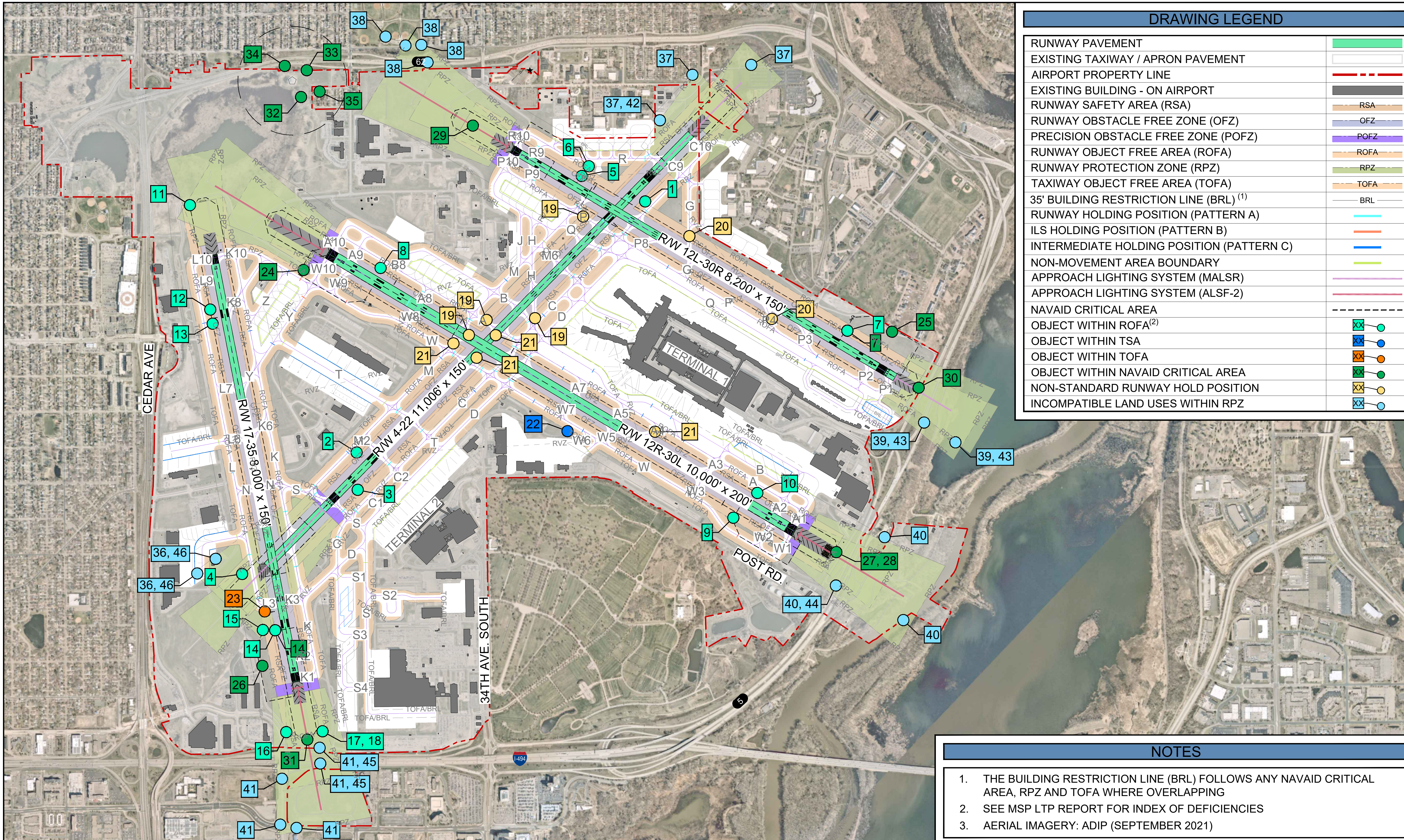
Very High Frequency Omni-Directional Range (VOR) / Distance Measuring Equipment (DME) Critical Area

There is also a critical area associated with the MSP VOR/DME facility. Generally, this critical area is defined by a 1,000-foot radius from the facility, but there are additional restrictions on permitted land uses, types of structures, and heights of objects near the MSP VOR/DME.

- Individual trees and groups of trees are within the VOR/DME critical area (identified on **Exhibit 3-10** as Items 32 and 33). All vegetation within this critical area should be managed or trimmed, as appropriate, to comply with FAA Order 6820.10, VOR, VOR/DME, and VORTAC Siting Criteria.
- There are off-Airport light poles, off-Airport freeway signage, fences, and off-Airport buildings or houses within the VOR/DME critical area (identified on **Exhibit 3-10** as Items 34 and 35). All such structures should be confirmed to be made of materials compliant with the guidance in FAA Order 6820.10 and should not exceed the pertinent height limitations.

The LTP does not propose any targeted mitigation for the objects within the VOR/DME critical area. The VOR/DME is continuously monitored and checked, and the identified objects have not caused known interferences detrimental to the VOR/DME performance.

The MSP VOR is on the FAA's list for decommissioning. The MSP VOR was included in Phase 2 of the VOR MON Program Discontinuance list, which was published in the *Federal Register* in July 2016. Phase 2 of the VOR discontinuance schedule covered fiscal year (FY) 2021 through FY 2025.



DRAWING LEGEND

- RUNWAY PAVEMENT
- EXISTING TAXIWAY / APRON PAVEMENT
- AIRPORT PROPERTY LINE
- EXISTING BUILDING - ON AIRPORT
- RUNWAY SAFETY AREA (RSA) — RSA
- RUNWAY OBSTACLE FREE ZONE (OFZ) — OFZ
- PRECISION OBSTACLE FREE ZONE (POFZ) — POFZ
- RUNWAY OBJECT FREE AREA (ROFA) — ROFA
- RUNWAY PROTECTION ZONE (RPZ) — RPZ
- TAXIWAY OBJECT FREE AREA (TOFA) — TOFA
- 35' BUILDING RESTRICTION LINE (BRL) (1) — BRL
- RUNWAY HOLDING POSITION (PATTERN A)
- ILS HOLDING POSITION (PATTERN B)
- INTERMEDIATE HOLDING POSITION (PATTERN C)
- NON-MOVEMENT AREA BOUNDARY
- APPROACH LIGHTING SYSTEM (MALSR)
- APPROACH LIGHTING SYSTEM (ALSF-2)
- NAVAID CRITICAL AREA
- OBJECT WITHIN ROFA (2) — XX
- OBJECT WITHIN TSA — XX
- OBJECT WITHIN TOFA — XX
- OBJECT WITHIN NAVAID CRITICAL AREA — XX
- NON-STANDARD RUNWAY HOLD POSITION — XX
- INCOMPATIBLE LAND USES WITHIN RPZ — XX

NOTES

1. THE BUILDING RESTRICTION LINE (BRL) FOLLOWS ANY NAVAID CRITICAL AREA, RPZ AND TOFA WHERE OVERLAPPING
2. SEE MSP LTP REPORT FOR INDEX OF DEFICIENCIES
3. AERIAL IMAGERY: ADIP (SEPTEMBER 2021)

N

0 1,600' 3,200'

MSP
MAC
MINNEAPOLIS-SAINT PAUL INTERNATIONAL AIRPORT
2040 LONG-TERM PLAN

FEBRUARY 2023

EXHIBIT 3-10

AIRFIELD STANDARDS REVIEW

3.3.5 Airfield Capacity

For long-term planning purposes at large airports with multiple operating configurations and high levels of traffic, the FAA recommends use of sophisticated simulation modeling analysis to ascertain airport capacity to more accurately assess capacity compared to annual service volume (ASV) calculations and spreadsheet-based models that do not fully capture the intricacies of a large-hub operation.

3.3.5.1 Baseline Simulation Model Development

In September 2020, a comprehensive airfield capacity study (capacity study) was finalized under separate task authorization, in which the MAC completed a fast-time airfield simulation model using AirTOP. The objectives of this study included developing predictions of how much of the existing MSP airfield capacity is needed to accommodate existing and forecast demand levels as well as estimate associated levels of delay. For this analysis, summer DDFS were developed based on aviation activity forecasts completed for the MSP 2040 LTP. Four DDFS were developed, including 2018 and future PAL 3. **Table 3-60** lists the corresponding aircraft operations associated with each PAL.

Table 3-60: Forecast Annual Aircraft Operations by Planning Activity Level

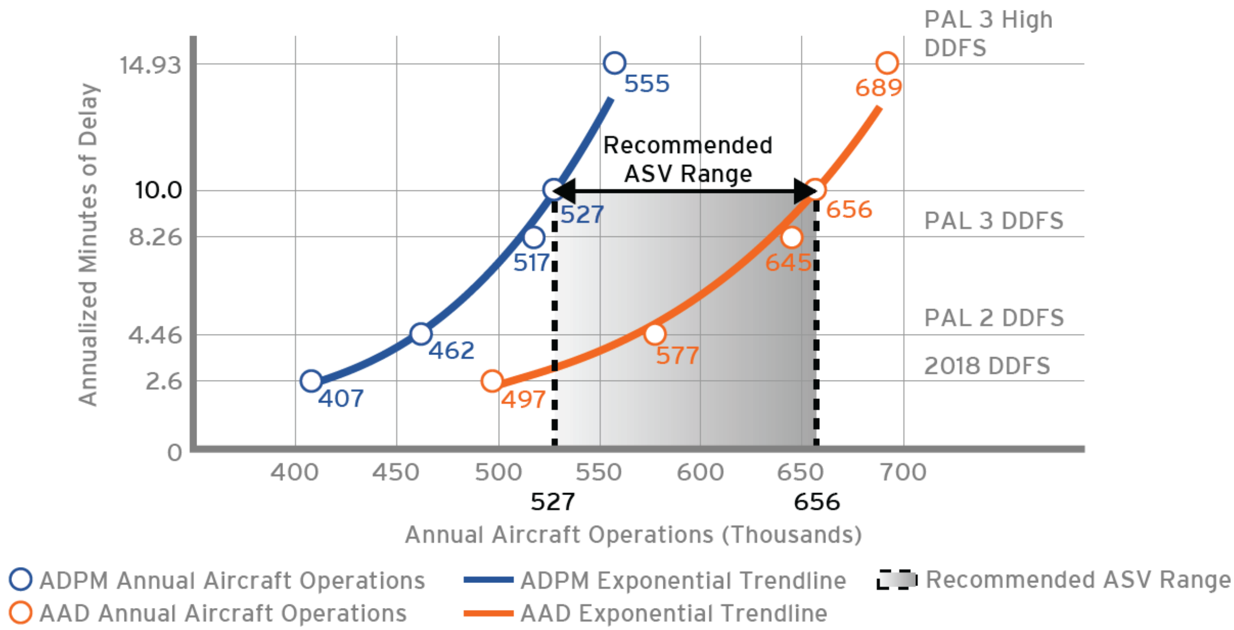
Activity Level	Total Annual Operations
2018	407,394
PAL 1 (2025)	462,000
PAL 2 (2030)	517,000
PAL 3 (2040)	555,000

NOTE:
PAL – Planning Activity Level
SOURCE: Ricondo and Associates, MSP 2040 LTP Revised Forecast, 2022

3.3.5.2 Average Annual Day and Average Day Peak Month

To facilitate dialogue among multiple groups of stakeholders, this capacity study evaluated capacity based on demand on an average annual day (AAD), which is typical for environmental-focused studies, and demand on an average day peak month (ADPM) basis, which is typical for capacity studies. Both metrics present variations in the determination of ASV and delay. Recognizing these variations, ADPM and AAD capacity curves were developed to visualize and determine ASV; these curves are shown on **Exhibit 3-11**.

Exhibit 3-11: Annual Service Volume Ranges



NOTES:
PAL – Planning Activity Level; DDFS – Design Day Flight Schedule; ADPM – Average Day Peak Month; AAD – Average Annual Day; ASV – Annual Service Volume
SOURCES: HNTB Corporation, 2020 (analysis); MSP Long-Term Plan Airfield Capacity Study, December 2020.

The resulting recommended ASV range was 527,000 to 656,000 operations with current technologies and ATC procedure assumptions in place. An ASV range is provided since the LOS desired needs to factor into the amount of delay that will be considered tolerable. AAD and ADPM analyses have differing delay recovery times. Based on this capacity study's findings, there was no demonstrated need for additional runways or a replacement Airport within and beyond the 20-year planning period. The capacity study concluded that, as part of the LTP, incremental improvements to improve efficiency and reduce delays will be explored through modest improvements to airfield geometry, technology, and policy.

3.3.6 Runway Incursion Mitigation and Hot Spots

The following subsections describe the existing hot spots on the airfield, as well as the incident history from 2011 to 2021. In addition, specific characteristics in the airfield geometry have been identified that may contribute to the risk of surface incidents and/or runway incursions.

3.3.6.1 Federal Aviation Administration Hot Spots

A hot spot is typically identified as a complex or confusing taxiway-runway or taxiway-taxiway intersection, which has an increased risk or history of or potential risk for runway incursions and incidents, which can be due to airport layout or geometry, traffic flow, or airport marking signage and lighting, which requires heightened attention by pilots and drivers. These hot spots are identified and defined by the Runway Safety Action Team that analyzes the airport's history of runway incursions and incidents. MSP has three official hot spots. **Exhibit 3-12** shows the currently published hot spots at MSP. **Table 3-61** describes each hot spot.

Table 3-61: Federal Aviation Administration Hot Spots Description

Hot Spot	Location	Description
HS 1	Runway 4-22 / Runway 12R-30L intersection	Taxiway A, Taxiway B, Taxiway C, Taxiway D, Taxiway H, Runway 4-22, and Runway 12R-30L – complex geometry
HS 2	Runway 4-22 / Runway 12L-30R intersection	Complex geometry at the intersection of Taxiway C, Taxiway P8, Taxiway D, Taxiway P, Taxiway Q, and the Runway 4-22 and Runway 12L-30R intersection – rqr caution for runway crossings in this area
HS 3	12R / W10 intersection	Taxiway/runway geometry and traffic flow

NOTE:
HS – Hot Spot
SOURCE: U.S. Department of Transportation, FAA, November 2022.

3.3.6.2 Runway Incursions and Surface Incident History

The FAA defines surface incidents and runway incursions as follows:

- **Surface Incident** – Any event where unauthorized or unapproved movement occurs within the airport movement area, or an occurrence in the movement area associated with the operation of an aircraft that affects or could affect the safety of flight. A surface incident can occur anywhere on the airport's surface, including the runway.
- **Runway Incursion** – Any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and takeoff of aircraft.

As shown in **Table 3-62**, the FAA has adopted four categories of runway incursions, with category "A" being the most severe classification.

Table 3-62: Federal Aviation Administration Runway Incursion Severity Categories

Severity Classification	Description
A	A serious incident in which a collision was narrowly avoided
B	An incident in which separation decreases and there is a significant potential for collision, which may result in a time-critical corrective/evasive response to avoid a collision
C	An incident characterized by ample time and/or distance to avoid a collision
D	An incident that meets the definition of a runway incursion, such as incorrect presence of a single vehicle/person/aircraft on the protected area of a surface designated for the landing and takeoff of aircraft but with no immediate safety consequences

SOURCE: U.S. Department of Transportation, FAA, November 2022.

Types of incidents that are used to identify the primary cause of an incident include the following:

- **Operational Incidents (OI)** – Action of an ATCT that results in the following: less-than-required minimum separation between two or more aircraft or between an aircraft and obstacles, (vehicles, equipment, personnel on runways) or clearing an aircraft to take off or land on a closed runway. The majority of aircraft incidents at MSP were related to operational incidents, specifically loss of aircraft separation.
- **Pilot Deviations (PD)** – Action of a pilot that violates any CFR. Example: a pilot crosses a runway without a clearance while enroute to an airport gate.

- **Vehicle/Pedestrian Deviations (V/PD)** – Pedestrians or vehicles entering any portion of the airport movement areas (runways/taxiways) without authorization from ATC.

Table 3-63 and **Table 3-64** summarize the incursions and surface incidents that occurred over a 10-year period from 2011 to 2021.

Table 3-63: Incursion and Incident Summary – 2011 through 2021

Year	Airspace Conflict	A	B	C	D	SI	Total
2011	0	0	0	3	3	2	**8**
2012	0	0	0	12	0	1	**13**
2013	0	0	1	6	5	0	**12**
2014	0	0	0	4	0	1	**5**
2015	0	0	0	11	0	1	**12**
2016	0	0	0	27	4	1	**32**
2017	2	0	0	25	5	0	**32**
2018	0	0	0	7	7	0	**14**
2019	1	0	0	2	5	0	**8**
2020	0	0	0	4	5	0	**9**
2021	0	0	0	1	1	0	**2**
Total	**3**	**0**	**1**	**102**	**35**	**6**	**147**

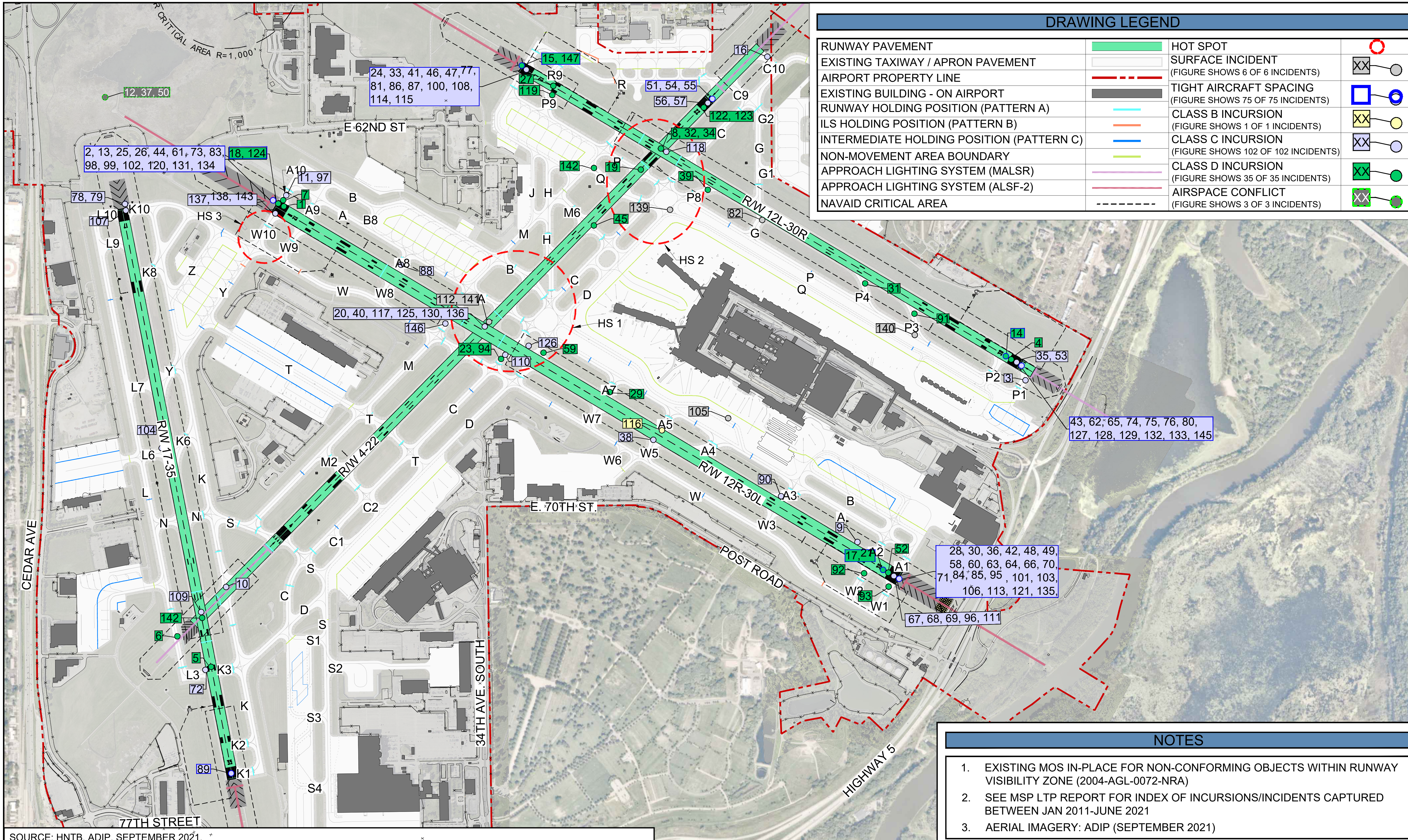
NOTES:
SI – Surface Incident
SOURCES: U.S. Department of Transportation, FAA, Runway Incursion Database, 2022; HNTB Corporation, November 2022 (analysis).

Table 3-64: Incident Type – 2011 through 2021

Year	OI	PD	V/PD	Total
2011	3	2	3	**8**
2012	9	4	0	**13**
2013	3	5	4	**12**
2014	4	1	0	**5**
2015	9	2	1	**12**
2016	22	4	6	**32**
2017	22	8	2	**32**
2018	8	5	1	**14**
2019	4	3	1	**8**
2020	0	3	6	**9**
2021	1	1	0	**2**
Total	**85**	**38**	**24**	**147**

NOTES:
OI – Operational Incident; PD – Pilot Deviation; VPD – Vehicle/Pedestrian Deviation
SOURCES: U.S. Department of Transportation, FAA, Runway Incursion Database, 2022; HNTB Corporation, November 2022 (analysis).

Exhibit 3-12 graphically depicts the incursions and incidents.



DRAWING LEGEND

RUNWAY PAVEMENT		HOT SPOT	
EXISTING TAXIWAY / APRON PAVEMENT		SURFACE INCIDENT (FIGURE SHOWS 6 OF 6 INCIDENTS)	XX
AIRPORT PROPERTY LINE		TIGHT AIRCRAFT SPACING (FIGURE SHOWS 75 OF 75 INCIDENTS)	
EXISTING BUILDING - ON AIRPORT		CLASS B INCURSION (FIGURE SHOWS 1 OF 1 INCIDENTS)	XX
RUNWAY HOLDING POSITION (PATTERN A)		CLASS C INCURSION (FIGURE SHOWS 102 OF 102 INCIDENTS)	XX
ILS HOLDING POSITION (PATTERN B)		CLASS D INCURSION (FIGURE SHOWS 35 OF 35 INCIDENTS)	XX
INTERMEDIATE HOLDING POSITION (PATTERN C)		AIRSPACE CONFLICT (FIGURE SHOWS 3 OF 3 INCIDENTS)	XX
NON-MOVEMENT AREA BOUNDARY			
APPROACH LIGHTING SYSTEM (MALSR)			
APPROACH LIGHTING SYSTEM (ALSF-2)			
NAVAID CRITICAL AREA			

NOTES

1. EXISTING MOS IN-PLACE FOR NON-CONFORMING OBJECTS WITHIN RUNWAY VISIBILITY ZONE (2004-AGL-0072-NRA)
2. SEE MSP LTP REPORT FOR INDEX OF INCURSIONS/INCIDENTS CAPTURED BETWEEN JAN 2011-JUNE 2021
3. AERIAL IMAGERY: ADIP (SEPTEMBER 2021)

SOURCE: HNTB, ADIP, SEPTEMBER 2021.

0 1,200' 2,400'

N

MSP MINNEAPOLIS-SAINT PAUL INTERNATIONAL AIRPORT
2040 LONG-TERM PLAN

MAC METROPOLITAN AIRPORTS COMMISSION

OCTOBER 2022

EXHIBIT3–12
INCURSION/INCIDENT SEVERITY MAP

3.3.6.3 Geometric Contributing Factors

FAA AC 150/5300-13B, *Airport Design*, consolidates many recent research findings related to airfield safety, and this information is supplemented by other FAA documentation. Previously, several airfield safety enhancement bulletins had been published in FAA Orders and Engineering Briefs, and many of these remain relevant, as does documentation associated with the FAA national runway incursion program office. The research correlates existing design geometries with incursion history, as well as the future potential for an incursion to take place. The FAA determined there are specific characteristics in airfield geometry that can contribute to the potential for both surface incidents and runway incursions.

In addition to the FAA hot spots, additional airfield geometries do not meet current FAA AC 150/5300-13B guidelines, which result in the potential for incursions. These non-standard geometries are inclusive of those identified by the FAA RIM Data Management Tool, which includes a high-level analysis of non-standard geometries at MSP. **Exhibit 3-13** graphically depicts the geometric contributing factors.

- **High-Energy Runway Crossings** – Aircraft should not have runway crossing points in the middle-third of the runway to provide enhanced pilot situational awareness. At MSP, 12 high-energy runway crossings are at the following locations:
  - Runway 4-22 at Taxiways T, W, A, B, H
  - Runway 12L-30R at Taxiway G
  - Runway 12R-20L at Taxiways C, D, A7/W7, A5/W5
  - Runway 17-35 at Taxiways L6/K6, N

The LTP does not propose targeted mitigation to remove any of the high-energy runway crossings. Removal of these taxiways would have significant impacts to the Airport's capacity. Over half of the incursions reviewed had an operational incident noted as the primary cause. The number of incursions has also dramatically dropped in the last several years, potentially resulting from revised ATC procedures. A review of the pilot deviation–coded incidents indicates these types of incursions occur throughout the airfield and are not isolated to the high-energy crossings. Therefore, the airfield geometry, specifically relating to high-energy crossings, does not elevate the risk of a runway incursion at these locations.

- **Direct Access** – Pilots could mistakenly cross a runway directly from an apron area without being cleared. At MSP, 18 locations have direct runway access from an apron or ramp area, as summarized in **Table 3-65**.

Table 3-65: Direct Access Summary

Taxiway	Apron	Runway	Mitigation
A1	Delta Maintenance	30L	Deice Pad Reconfiguration
A2	Delta Maintenance	12R-30L	None[1]
A3	30L Deice Pad	12R-30L	None[1]
A4	Concourse G	12R-30L	None[1]
A7	Concourse F/G	12R-30L	None[1]
A8	12R Deice Pad	12R-30L	None[2]
W6	General Aviation Ramp	12R-30L	None[3]
C2	T2 Apron	4-22	None[4]
C6	Concourse E/F	4-22	None[5]
S	T2 Apron	4	None[4]
T	T2 Apron	4-22	None[4]
L6	Cargo Apron	17-35	None[4]
H	12L Deice Pad	4-22	None[2]
P1	30R Deice Pad	12L-30R	None[2]
P2	Concourse A	12L-30R	None[1]
P9	12L Deice Pad	12L-30R	None[2]
G	Concourse D	12L-30R	None[1]
Q	12L Deice Pad	4-22	None[4]

NOTES:
1 At these locations, taxiing aircraft need to cross a parallel taxiway before reaching the runway environment, and they need to cross an area delineated by taxiway edge markings, both of which should increase pilot situational awareness.
2 There is only one deice position that has direct access to the runway environment without requiring a turning maneuver. From this position, the aircraft needs to cross a parallel taxiway prior to reaching the runway environment, which should increase situational awareness. It is not recommended to remove this deice position due to the resulting deicing capacity impact.
3 The only incursion near this location did not include an aircraft; it involved a vehicle entering the Runway 30L runway safety area from the general aviation ramp without contacting ATCT. The general aviation ramp is removed from this location in the preferred development alternative.
4 Aircraft need to cross a parallel taxiway prior to reaching the runway environment, which should increase situational awareness.
5 Aircraft taxiing from the future terminal apron will need to cross two parallel taxiways prior to reaching the runway environment, which should increase situational awareness.
SOURCES: U.S. Department of Transportation, FAA, Runway Incursion Database, 2022; HNTB Corporation, November 2022 (analysis).

All runways include hold position markings and runway guard lights, which also enhances situational awareness for pilots taxiing in these areas.

Wide Expanse of Pavement – Wide expanses of pavement can result in a loss of situational awareness and may result in visual cues (signs, markings, lights) being placed outside or far from a pilot's field of vision. At MSP, five identified areas are a wide expanse of pavement:

- Areas between Taxiways A and B. Taxiway edge markings are present along both Taxiway A and Taxiway B, reducing the risk of non-channelized taxiing and wingtip conflicts. The LTP does not propose the addition of physical or no-taxi islands, as the ATCT often utilizes this pavement to cross over aircraft to reduce delays and queuing.
- The intersection of Taxiways A, B, C, and D. The LTP does not propose any action at this location. The island is being studied as part of a separate MAC assignment, and any mitigations will be proposed as part of that effort.
- Sections between Taxiways P and Q. Taxiway edge markings are present along both Taxiway P and Taxiway Q, reducing the risk of non-channelized taxiing and wingtip conflicts. The LTP

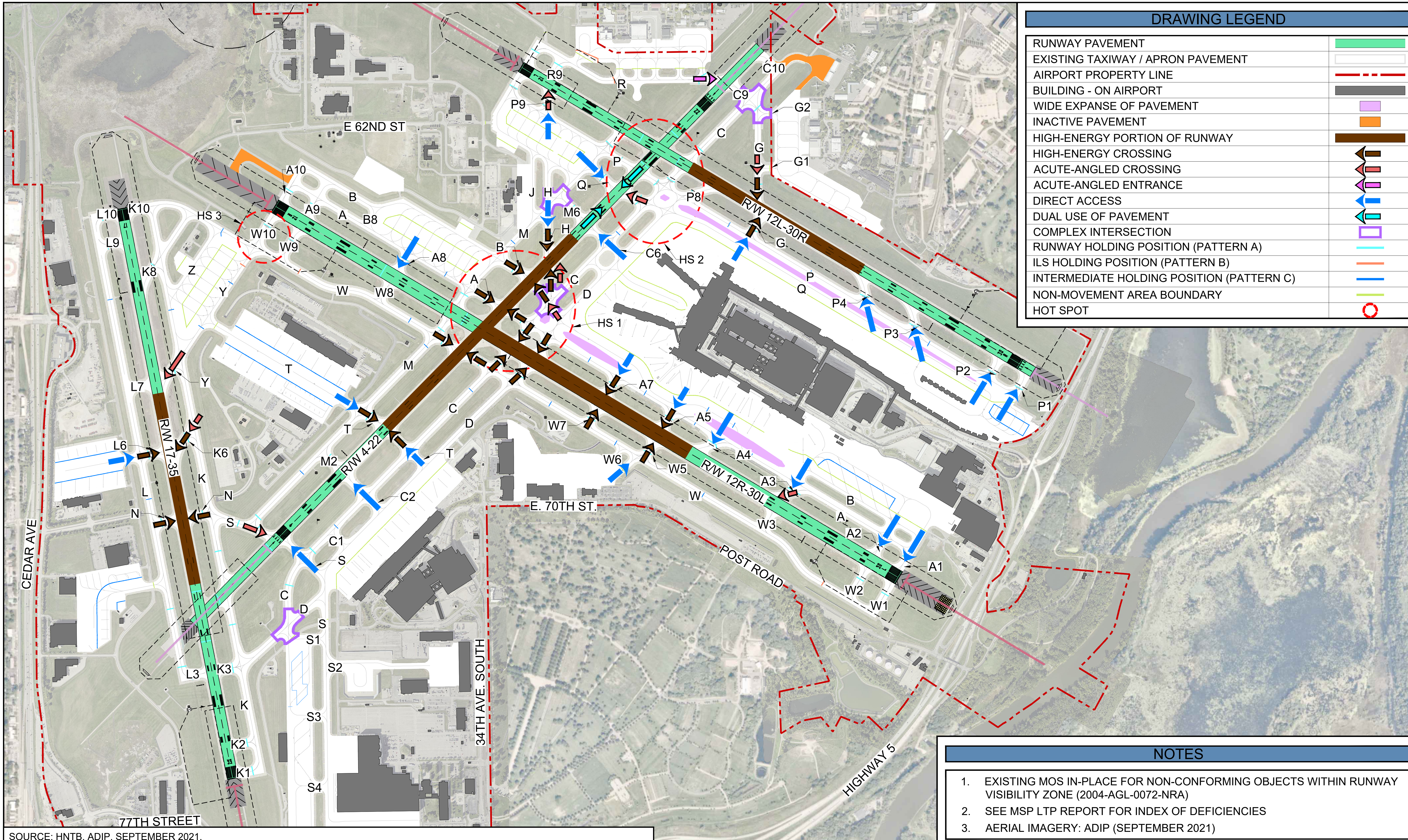
does not propose the addition of physical or no-taxi islands, as the ATCT often utilizes this pavement to cross over aircraft to reduce delays and queuing.

- Intersection between Taxiways P, Q, C, and D. The LTP does not propose any action at this location. The island is being studied as part of a separate MAC assignment, and any mitigations will be proposed as part of that effort.

It should be noted that all other taxiways have designated no-taxi islands that are intended to mitigate each area's wide expanse of pavement.

- **Acute-Angled Crossing** – Right angles provide the best visibility left and right for a pilot at an intersection. At MSP, there are seven acute-angled crossing locations:
  - Runway 4-22 at Taxiway R. The LTP does not propose any realignment of the taxiway. There were no incidents at this location within the timeframe analyzed. The MAC may consider realigning the taxiway the next time it is rehabilitated.
  - Runway 4-22 at Taxiway S. The LTP does not propose any realignment of the taxiway. There were no incidents at this location within the timeframe analyzed. The MAC may consider realigning the taxiway the next time it is rehabilitated.
  - Runway 12L-30R at Taxiway P9. The LTP does not propose any realignment of the taxiway. There were two incidents at this location within the timeframe analyzed. One incident was the result of a mistaken call sign, and the second was the pilot of a General Aviation (GA) aircraft who became confused at the taxi instructions to taxi across the deice pad and on to Taxiway P. Neither incident was the result of the acute angle of Taxiway P9. The MAC may consider realigning the taxiway the next time it is rehabilitated.
  - Runway 12L-30R at Taxiway G. As part of a future taxiway project in the preferred development alternative, this acute-angled crossing is replaced with a 90-degree crossing. There were no incidents within the timeframe analyzed on Taxiway G at the acute-angled crossing location.
  - Runway 12R-30L at Taxiway A3. The LTP does not propose any realignment of the taxiway since Taxiway A3 is a high-speed exit taxiway. There was one incident within the timeframe analyzed at Taxiway A3; however, the incident involved snow removal equipment that passed beyond the hold position markings and held short of the runway within the RSA.
  - Runway 17-35 at Taxiway K6. The LTP does not propose any realignment of the taxiway since Taxiway K6 is a high-speed exit taxiway. There were no incidents at this location within the timeframe analyzed.
  - Runway 17-35 at Taxiway Y. The LTP does not propose any realignment of the taxiway since Taxiway Y is a high-speed exit taxiway. There were no incidents at this location within the timeframe analyzed.
- **Acute-Angled Entrance** – Pilots approaching a runway sometimes mistakenly line up for approach on the parallel taxiway. Rounding out the entrance taxiway to a runway visually enhances both the taxiway and runway. There is one acute-angled entrance located at the approach end of Runway 22 at Taxiway R. The LTP does not propose any realignment of the taxiway. There were no incidents at this location within the timeframe analyzed. The MAC may consider realigning the taxiway the next time it is rehabilitated.

- **Complex Intersection** – Pilots could mistakenly traverse the wrong taxiway at taxiway intersections where there are greater than two intersecting paths. There are four complex intersections that have more than three nodes, which can lead to pilot confusion, and if located near a runway entrance can cause an incursion. These locations are as follows:
  - Taxiway C at Taxiway G intersection. The LTP does not propose any geometric improvements at this intersection. There were no incidents at this location within the timeframe analyzed. The MAC may consider geometric improvements the next time this intersection is rehabilitated, or it may choose to extend the limits of the project shown for Taxiway G in the preferred development alternative.
  - Taxiways M, H, and M6 intersection. The LTP does not propose any geometric improvements at this intersection. There were no incidents at this location within the timeframe analyzed. The MAC may consider geometric improvements at this location the next time the intersection is rehabilitated. However, capacity impacts will need to be considered if taxiways are removed to create a three-node intersection.
  - Taxiways C, D, H, and B intersection. The LTP does not propose any geometric improvements at this intersection. There were no incidents at this location within the timeframe analyzed. The wide expanse of pavement in this vicinity is being studied by the MAC under a separate task assignment. That task may recommend geometric improvements at this intersection to address the wide expanse of pavement and complex intersection.
  - Taxiways C, D, and S1 intersection. The LTP does not propose any geometric improvements at this intersection. There were no incidents at this location within the timeframe analyzed. The MAC may consider geometric improvements at this location the next time the intersection is rehabilitated. However, capacity impacts will need to be considered if taxiways are removed to create a three-node intersection.
- **Dual Use of Pavement** – Runways should always be used solely as runways, and taxiways should always be used solely as taxiways, without mixing of uses or "dual purposes" (i.e., a runway being used as a taxiway and a taxiway being used as a runway). There is one area of dual use pavement located on Runway 4-22 between Taxiway C6 and Taxiway Q. Runway 4-22 is sometimes used as an exit taxiway for arriving aircraft landing on Runways 30L and 30R. It is also sometimes used as a hot-holding location when aircraft are waiting for their arrival gate to open. The LTP does not propose revising the dual use of Runway 4-22, as it is required for the operational and capacity needs of MSP. Sections of Runway 4-22 are equipped with taxiway edge lights to increase situational awareness when the runway is being used for taxiing operations.



DRAWING LEGEND

RUNWAY PAVEMENT	
EXISTING TAXIWAY / APRON PAVEMENT	
AIRPORT PROPERTY LINE	
BUILDING - ON AIRPORT	
WIDE EXPANSE OF PAVEMENT	
INACTIVE PAVEMENT	
HIGH-ENERGY PORTION OF RUNWAY	
HIGH-ENERGY CROSSING	
ACUTE-ANGLED CROSSING	
ACUTE-ANGLED ENTRANCE	
DIRECT ACCESS	
DUAL USE OF PAVEMENT	
COMPLEX INTERSECTION	
RUNWAY HOLDING POSITION (PATTERN A)	
ILS HOLDING POSITION (PATTERN B)	
INTERMEDIATE HOLDING POSITION (PATTERN C)	
NON-MOVEMENT AREA BOUNDARY	
HOT SPOT	

NOTES

1. EXISTING MOS IN-PLACE FOR NON-CONFORMING OBJECTS WITHIN RUNWAY VISIBILITY ZONE (2004-AGL-0072-NRA)
2. SEE MSP LTP REPORT FOR INDEX OF DEFICIENCIES
3. AERIAL IMAGERY: ADIP (SEPTEMBER 2021)

SOURCE: HNTB, ADIP, SEPTEMBER 2021.

MSP
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2040 LONG-TERM PLAN

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0 1,200' 2,400'

OCTOBER 2022

EXHIBIT 3-13

GEOMETRIC CONTRIBUTING FACTORS / HOT SPOT MAP

3.3.7 Deice Pads and Remain-Overnight Parking

At a minimum, the LTP aims to retain the existing number of deice positions and RON parking positions. A reduction in either the number of deice positions or the number of RON positions is not operationally feasible with the anticipated traffic levels at the forecast horizon. The 2020 MSP capacity study modeled the existing deicing operations at PAL 2. The simulation showed the existing deice positions could accommodate the PAL 2 traffic levels; however, some aircraft were required to be held at their gates to avoid overflow conflicts at the deice pads. The preferred airfield layout, discussed in Chapter 4, provides for additional deice and RON capacity, where feasible, considering terminal expansion needs.

3.3.8 Air Traffic Control Tower Line of Sight

As MSP is a Part 139-certified airport with an operating ATCT, ATCT personnel require an unobstructed view from the cab of the ATCT to the movement area, including taxiways and runways, as well as the non-movement area boundary line. The ATCT and top cab should be located to provide a view to all points of the movement area and should preclude parked aircraft, buildings, and equipment from obstructing a controller's view.

The LTP does not propose any improvements to or relocation of the ATCT. Existing line-of-sight concerns related to seeing the far ends of Concourses A and G may be mitigated by local Ramp Control at the far ends of the concourses where aircraft can be directed to a designated location prior to contacting Ground Control.

3.3.9 Cargo Requirements

As previously mentioned, the Air Cargo Assessment Study was conducted in September 2021 by Landrum & Brown, Inc. The results of the facility demand/capacity analysis from the cargo study were used for this update of the LTP. The facility requirements were segmented by building and carrier. The existing air cargo facilities at MSP represent approximately 522,678 square feet of total cargo building area. **Table 3-66** shows the segmented carriers and their respective building, apron, and landside areas, as well as each carrier's 2020 tonnage throughput.

Table 3-66: Existing Air Cargo Facilities at the Airport

Building	Carrier	Building (Sq Ft)	Apron (Sq Ft)	Landside/Other (Sq Ft)	2020 Metric Tonnes
FedEx	FedEx	203,000	341,000	522,540	89,793
UPS	UPS	67,000	406,128	558,374	70,566
Delta	Main Delta Cargo	104,036	-	585,698	18,365
	Delta Dash	2,064	-	33,000	
DHL	Amazon (Atlas Air / Sun Country)	3,009	240,000	54,828	12,216
	DHL	33,284			7,531
	WFS	10,134			Handler Only
Sun Country HQ	Sun Country (belly/Amazon)	6,165	-	Shared	1,837
Air Cargo Center	Other/WFS	23,953	-	Shared	3,389
	Southwest	7,458	-	Shared	
	Air General	7,575	-	Shared	
	Vacant (old DHL)	55,000	-	Shared	-
	Total	522,678	987,128		203,697

SOURCE: Landrum & Brown, Inc., *Air Cargo Assessment Study*, September 2021.

The industry standards for throughput ratio indicate a normal processing rate of 1 ton of cargo per square foot of warehouse per year. Individual carrier practices and many other factors can impact throughput ratios. Each cargo facility at MSP has different space utilization; therefore, each carrier was categorized into carrier groupings and relative utilization. **Exhibit 3-14** shows these carrier groupings.

Exhibit 3-14: Carrier Groupings

RELATIVE UTILIZATION	CARRIER GROUPING
Higher	Integrator
	All-Cargo Airline
	Domestic Combination
	Domestic Passenger
	International Combination
Lower	International Passenger

SOURCE: Landrum & Brown, Inc., *Air Cargo Assessment Study*, September 2021.

The MAC conducted a theoretical capacity analysis to determine if the existing facilities could accommodate the projected growth in throughput. An estimated throughput ratio was assigned to each carrier based on the different carrier groupings and those assigned throughput ratios. This analysis concluded that the existing facilities could accommodate up to an estimated 600,000 metric tonnes of cargo per year, based on minimum efficient throughput levels from historical industry averages. This suggests that the existing facilities at MSP can handle the air cargo forecast of 394,199 metric tonnes. **Table 3-67** shows the theoretical capacity results for the legacy carriers.

Table 3-67: Theoretical Capacity for Legacy Carriers

Building	Main Tenants	Building (Sq Ft)	Estimated (MT[1] Sq Ft / Year)	Estimated Throughput (MTs)
FedEx	FedEx	203,000	1.5	304,500
UPS	UPS	67,000	1.5	100,500
Delta (Main and Dash)	Delta	106,100	0.75	79,575
DHL	Amazon / DHL	46,427	1.0	46,427
Air Cargo Center	Air General / WFS / Southwest	93,986[2]	0.75	70,489
Sun Country HQ	Sun Country (belly)	6,165	0.75	4,624
	Total Estimate	522,678		606,115

NOTES:
1 MT – Metric Tonnes
2 This includes 55,000 square feet of empty space in the building.
SOURCE: Landrum & Brown, Inc., *Air Cargo Assessment Study*, September 2021.

Cargo requirements were evaluated for the 2030 and 2040 planning horizons. Each carrier has its own set of requirements, which consist of warehouse space, office space, aircraft ramp, auto parking, truck apron, and other miscellaneous space.

Table 3-68 presents the individual carrier cargo requirements. Amazon was the only carrier that did not have enough existing facility space to accommodate projected growth. Amazon currently occupies a 3,000-square-foot space in a shared facility with DHL. The 2040 requirements for Amazon indicate a demand for approximately 110,000 square feet of building footprint.

The Air Cargo Assessment Study concluded with the recommendation that the MAC focus its efforts on providing a future cargo footprint for Amazon expansion, as the existing cargo facilities at the Airport are capable of handling more than the projected growth through 2040.

Table 3-68: Air Cargo Study Individual Carrier Requirements

Main Carriers	Existing Estimated Sq Ft	2030	2040
Amazon			
Warehousing		73,800	99,200
Office		7,400	9,900
Other		3,700	5,000
Footprint	3,009	77,500	109,100
Aircraft Ramp	83,148	184,800	184,800
Auto Parking	17,400	28,800	38,700
Truck Apron	4,899	65,600	90,000
FedEx			
Warehousing		67,300	73,800
Office		6,700	7,400
Other		3,400	3,700
Footprint	203,000	70,700	80,600
Aircraft Ramp	376,937	231,000	277,200
Auto Parking	103,500	72,900	72,900
Truck Apron	75,053	60,000	65,600
UPS			
Warehousing		60,500	56,700
Office		6,100	5,700
Other		3,000	2,800
Footprint	67,000	63,500	62,400
Aircraft Ramp	451,950	237,300	283,500
Auto Parking	74,400	50,400	50,400
Truck Apron	61,917	52,500	65,600
DHL			
Warehousing		10,800	14,200
Office		1,100	1,400
Other		600	700
Footprint	43,418	11,400	14,900
Aircraft Ramp	124,722	138,600	138,600
Auto Parking	28,200	4,200	5,400
Truck Apron	7,735	5,600	9,400
Delta / Other Belly			
Warehousing		86,000	105,600
Office		8,600	10,600
Other		4,300	5,200
Footprint	106,100	90,300	110,800
Aircraft Ramp	N/A	0	0
Auto Parking	87,600	33,600	41,400
Truck Apron	71,094 + 14,792 (Bldg. H) = 85,886	76,900	95,600
Other All-Cargo			
Warehousing		1,000	1,000
Office		100	100
Other		100	100
Footprint	43,036	1,200[1]	1,200[1]
Aircraft Ramp *(shared with DHL)*	N/A	*46,200*	*46,200*
Auto Parking	36,933 (Bldg. H) + 19,081 (Bldg. I) = 56,014	3,000	3,600
Truck Apron	14,792 (Bldg. I)	3,800*	3,800*

NOTES: 1 Estimated to the closest 100
N/A – Not Applicable
SOURCE: Landrum & Brown, Inc., *Air Cargo Assessment Study*, September 2021.