Chapter 3. Operations Counting and Forecasting

3.1. Introduction

Forecasting aviation demand is a fundamental component of aviation system planning. Forecasting can help identify areas within the state that may face capacity constraints over the selected forecast horizon and support short- and mid-term operational planning to mitigate against anticipated deficiencies. These same objectives also play an important role in the identification of aviation investment needs at individual airport and statewide levels.

Forecasts can be developed for various indicators of aviation activity including commercial enplanements, based aircraft, or aircraft operations.[1] The 2022 Minnesota State Aviation System Plan (MnSASP or 2022 MnSASP) focuses specifically on aircraft operations at the 124 general aviation (GA) airports in the state aviation system.[2] This indicator of aviation demand is important because the number and type of operations experienced by an airport can influence the facilities and services that should be provided to optimally accommodate such activity. For example, airports anticipated to witness significant growth in the number and/or sophistication of aircraft utilizing their facilities may evaluate the need for a runway extension, pavement strengthening project, and/or additional storage facilities. In short, projecting future operations offers valuable insight into potential investment needs that may be required as demands change over time.

Identifying current operations is the first step of the forecasting process. Unfortunately, capturing these baseline operational counts at airports without an air traffic control tower (ATCT) is inherently difficult and the results are often inaccurate. GA airports that host a high percentage of operations conducted under Visual Flight Rules (VFR) are at a particular disadvantage, the reasons for which will be explored at length in the sections below. As such, this task of the MnSASP begins by exploring various strategies that may be employed at non-towered airports to estimate baseline operations. Following this investigation, a statewide methodology that offers a standard and uniform process for estimating baseline operations at Minnesota's non-towered GA airports is proposed.

Operational counts obtained using this process are then applied to forecast future activities at all publicly owned, public-use GA airports in the Minnesota state aviation system over the next 20 years. Forecasted operations are applied to operational thresholds established by the Minnesota Department of Transportation, Office of Aeronautics (MnDOT Aeronautics). These operational thresholds provide insight into when and what type of airport development needs may be required as operations reach certain annual levels by state classification. Finally, the chapter concludes by assessing airports currently supporting a significant number of operations by aircraft larger than their design codes. In such cases, additional improvements may be warranted to maintain airfield safety and operational efficiency.

[1] An aircraft operation is defined as a takeoff or landing. Therefore, one flight comprises two operations.

[2] Per the 2022 MnSASP scope approved by the FAA, the MnSASP only forecasted aircraft operations across Minnesota's 124 GA airports.

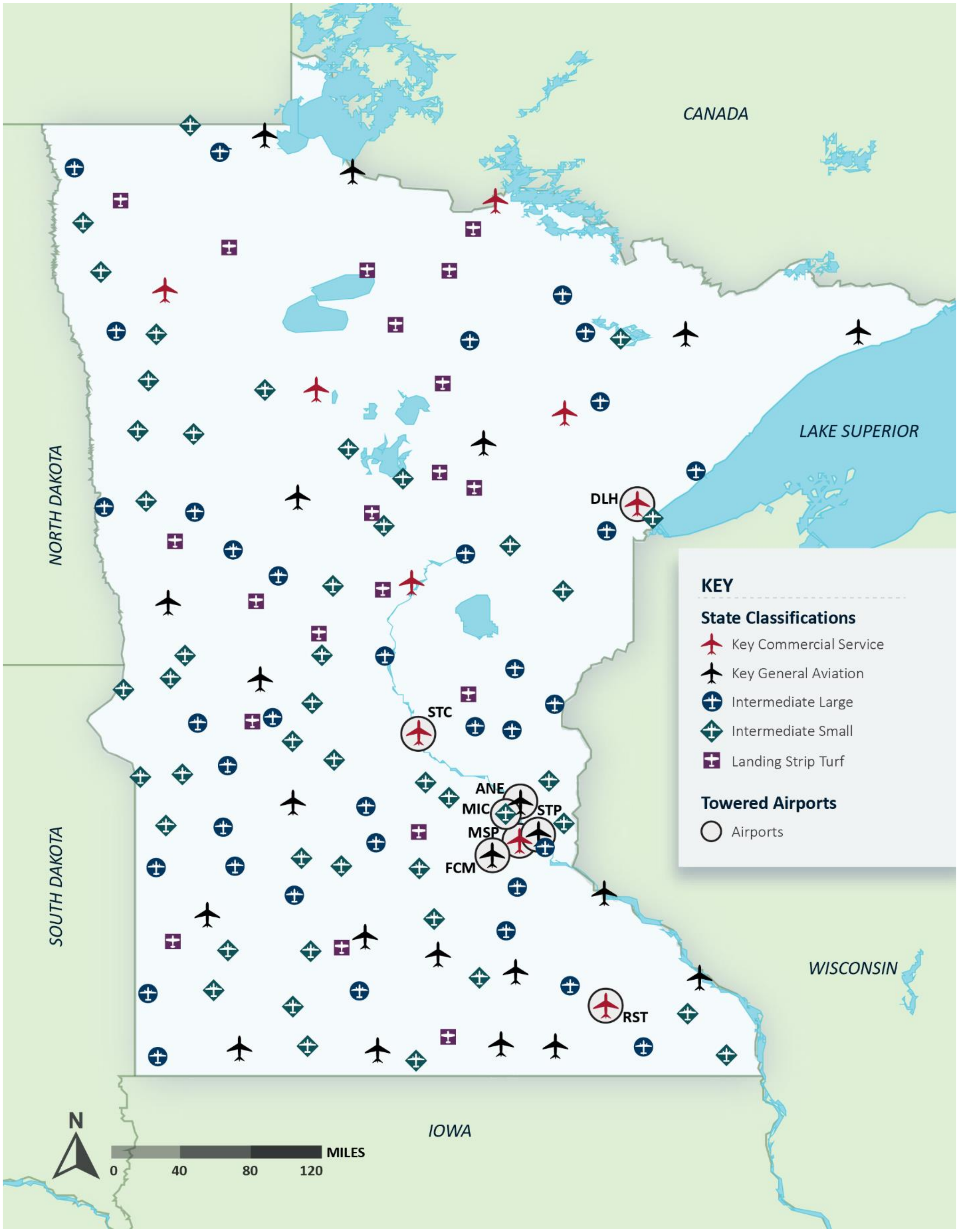
Accordingly, this chapter is organized as follows:

- Baseline Operations at GA Airports (Section 3.2)
- Forecasts of Aircraft Operations (Section 3.3)
- Operational Threshold Analysis (Section 3.4)
- Identification of Airports with Operations Exceeding Airport Reference Code (ARC) (**Section 3.5**)

It is important to emphasize several key points with the GA baseline operations and forecasts summarized in this chapter and detailed in **Appendix A**:

- This task specifically focuses on operations at the 124 GA airports in the Minnesota state aviation system. Commercial service airports typically conduct detailed, independent evaluations of future aviation activities at the airport-specific level for their own planning and investment purposes. As such, MnDOT Aeronautics is focusing its efforts on GA airports, of which 97 percent are non-towered (120 of 124). **Figure 3.1** depicts all 133 airports in the Minnesota state aviation system by classification, with the airports with an ATCT circled in red. GA airports with an ATCT include Minneapolis Flying Cloud (FCM), Minneapolis Anoka County/Blaine (ANE), Saint Paul Downtown Airport (Holman Field) (STP), and Minneapolis Crystal Airport (MIC).
- The GA operations forecasts were prepared at the same time as the evolving impacts of the COVID-19 public health emergency. The FAA's approval of the forecasts (issued on February 7, 2023) was based on the methodology, data, and conclusions at the time this document was prepared. However, consideration of the impacts of the COVID-19 public health emergency on aviation activity is warranted to acknowledge the reduced confidence in growth projections using currently available data.
- The FAA approved the GA operations forecasts on February 7, 2023. This approval does not constitute justification for future projects. Justification for future projects will be made based on activity levels at the time the project is requested for development. Documentation of actual activity levels meeting planning activity levels will be necessary to justify Federal funding for eligible projects.
- All GA airport operations estimates and forecasts presented in the 2022 MnSASP shall not be used for individual airport planning or funding decisions. Each airport is expected to prepare their own aviation activity forecast for FAA review and approval as a basis for justifying the planning and proposed development identified in the airport sponsor's Capital Improvement Plan (CIP).

Figure 3.1. Airports with an ATCT in the Minnesota State Aviation System



Sources: MnDOT Aeronautics, 2021; FAA Airport Data and Information Portal (ADIP), 2021

3.2. Baseline Operations at GA Airports

Calculating baseline operations is a cornerstone of many aviation planning tasks, serving as the foundation upon which forecasts are developed. Because of their importance during planning and investment decision-making processes, forecasts must be reviewed or approved by the Federal Aviation Administration (FAA) during system and master planning, respectively. Yet despite their importance, calculating operations at non-towered airports is difficult and often a costly and time-consuming endeavor. This challenge is well-recognized in the field of aviation planning and has prompted the authorship of several Airport Cooperative Research Program (ACRP) studies. Studies on the topic include *Synthesis 4: Counting Operations at Non-towered Airports* (2007) and the updated *Report 129: Evaluating Methods for Counting Aircraft Operations at Non-towered Airports* (2015).

Since the 2015 study was released, new FAA regulations came into effect that promised to significantly enhance the quality and availability of operations data at all airports. Aircraft flying in controlled airspace and at certain altitudes in uncontrolled airspace were required to install Automatic Dependent Surveillance-Broadcast (ADS-B) out equipment no later than January 1, 2020 as part of the agency's NexGen initiative. While NextGen remains promising, several issues have complicated the program's efficacy in obtaining operational counts at many small airports. The accuracy of ADS-B data depends on the percent of aircraft using an airport that are ADS-B out-equipped, coverage provided by the receiver at the airport, and the type of operations being conducted. Notably, flight training and military operations are generally under-counted due to technological limitations. Further, pilots operating at rural GA airports, such as those outside of Minnesota's urban cores, rarely fly in controlled airspace. For these reasons, ADS-B technologies may someday offer a solution to the challenges faced by many non-towered airports but do not yet offer the level of accuracy significantly better than other types of available operational counting strategies.

Despite these improvements, non-towered airports are at a significant disadvantage in terms of obtaining accurate information about the type and number of operations occurring at their facilities. This includes 120 non-towered state system airports in Minnesota (four GA airports in the state system have an ATCT). In general, operations counting at non-towered airports involves either calculating numbers based on available data (e.g., filed flight plans, number/type of based aircraft, fuel sales, etc.) or deploying a technology-based solution such as acoustical counters and video-capturing devices, or conducting visual surveys. The following section provides an overview of such technologies, each of which can aid in estimating operations occurring at a particular airport. Then, a Minnesota-specific alternative is proposed that estimates operations using available data.

3.2.1. OPERATIONS COUNTING TECHNOLOGIES

Many operations counting technologies exist and vary widely in terms of how data are captured, processed, and reported out. The accuracy of the results also differs based on factors including, but not limited to, airfield layout, type(s) and volume of activity occurring, and airport staff's ability and available time to manipulate and process the data. Airports that are considering deploying an operations counting technology should carefully evaluate the available alternatives and select the options that most closely aligns with their unique needs. This often involves consultation with the manufacturers directly, who are generally in the best position to provide airport-specific information about performance characteristics, installation needs, device efficacy, pricing, and other considerations important in the selection process. Table 3.1 provides an overview of the most common operations counting technologies on the market today, with additional narrative following.

Table 3.1. Overview of Ops Counting Technologies

Methodology	Tool/Instrument (Product Name)	Provider	Description	Pros	Cons	Cost	Potentially Suitable Facility Condition(s)	Accuracy
Automated Acoustic Counters (AACs)	Automated acoustical counter (Aircraft Detection System [ADS] 4000 Phoenix)	Wilderness Systems and Technologies	This type of device operates by monitoring acoustic signals and recording only those that match an aircraft takeoff. This count of takeoffs is multiplied by two to calculate the total number of operations with the assumption that the aircraft will eventually terminate the flight at the same airport of origin.	1) Durability 2) Accuracy rate over 90 percent is possible 3) Low maintenance needs, including the ability to be untouched for several months, even in below-freezing temperatures	1) Difficulty in recording quieter aircraft 2) Multiple devices needed for longer runways 3) Difficulty in capturing touch-and-go operations 4) No supplemental aircraft information is provided by the device (e.g., no information about type of aircraft, etc.)	$4,950 per unit	Automated acoustical counters are generally best suited to airports with limited touch-go operations and a single runway less than 5,000 feet long. Airports with longer runways require multiple units to be deployed to accurately capture operations. This type of unit may be suitable for rural airports without on-site staff members due to low maintenance needs.	A study completed by the Florida Department of Transportation (FDOT) in 2018 deployed this type of device across eight GA airports. This assessment calculated an overall accuracy of 61 percent. The accuracy of results at individual airports ranged from 2 to 76 percent. ACRP Report 129 cites that accuracy can be as high as 90 percent if installed correctly and suitable facility conditions are met.
Radio Transmissions	General Audio Recording Device (G.A.R.D.)	Invisible Intelligence, LLC	G.A.R.D. monitors an airport's UNICOM frequency and uses automated recognition to identify and record airport traffic to a computer hard drive. The software uses an algorithm to analyze communications, and users input the estimated number of transmissions per arriving and departing aircraft. Based on user input and recordings, the software provides an estimated number of operations.	1) Accuracy can be high (up to 91 percent according in an FDOT study) 2) Testimonials from several GA airports describe the accuracy as high	1) Accuracy can vary greatly by the variance of radio communications at an airport. The higher the variance, the less accurate the system will be as the device uses a baseline number of transmissions inputted by the user 2) No supplemental aircraft information is provided by the device	$3,950 (software, interface box, operation count software, radio scanner, computer)	G.A.R.D. is best suited to airports that support a consistent type of operation, which may increase the accuracy of user-input settings impacting calculated results. Airports with significant flight training activity may not be the best candidates for this technology, as student pilots may transmit messages at a different rate than more experienced pilots. The system must be placed in the same room as the UNICOM system and next to a window. Metal roofs and white noise on frequency can affect the system's ability to record operations.	Based on the FDOT study completed in 2018, the overall accuracy was recorded at 85 percent. Individual airport accuracy ranged from 37 to 91 percent.
Video Imaging	Camera system, RADAR receiver, and flight plan tracker (VANTAGE)	Vector Airport Systems	VANTAGE is an automated aircraft identification and tracking system that utilizes a combination of ground-based video image detection (VID), RADAR, and other sources to detect operations. The VID system is able to capture N-numbers to provide details on specific aircraft, unlike many other available technologies.	1) Can capture aircraft N-numbers to obtain aircraft type, make, model for further analysis 2) Very accurate when combined with NextGen data (greater than 90 percent accuracy) 3) Backed by multiple data sources, allowing for all weather types and lighting conditions	1) Very expensive	$25,000+ for purchase and installation, $10,000+ annually to maintain	When combined with the NextGen data product provided by L3Harris, this package is designed to work with all airports that have installed a camera system (aircraft ID pods) on the airfield and an ADS-B receiver attached in a high place with good lateral clearance around.	L3Harris asserts that the NextGen data provide 99 percent accuracy, with the VANTAGE system backing up this claim. An ACRP report completed in 2015 reported accuracy results of 90 percent for the Vector system alone. The 2018 FDOT study tested the device at two airports and found the overall accuracy to be 89 percent with Vector alone (1,842 operations captured compared to 2,064 actual).

Methodology	Tool/Instrument (Product Name)	Provider	Description	Pros	Cons	Cost	Potentially Suitable Facility Condition(s)	Accuracy
Satellite Tracking	ADS-B Receivers, FAA's System Wide Information Management (SWIM) database, Radio Detection and Ranging (RADAR), multilateration tracking (MLAT)	FlightAware	FlightAware operates with company-issued and crowd-sourced ADS-B receivers to capture ADS-B and Mode S-equipped aircraft. Airports can purchase flight history reports to obtain historic activity. This technology pulls in data from the FAA's SWIM database and RADAR feeds to provide a "Hyperfeed" for airport and airspace operations.	1) Draws results from multiple sources beyond ADS-B 2) Option to purchase individual airport reports with up to a 36 -month history 3) Can be more cost-effective when purchased on a subscription basis	1) Can be expensive if reports are pulled frequently 2) Records touch-go-operations as one operation, rather than multiple for each landing or takeoff 3) Does not capture military operations	12-month reports can range from $450 for a Landing Strip Turf up to $4,500 for MSP (all without aircraft ownership data, which costs about 30 percent more)	Airports with limited touch-go operations and comprehensive tracking coverage are best suited for this technology. Refer to the following link for the latest coverage map: https://flightaware.com/adsb/coverage/#data-coverage.	No published statistics are available. Accuracy is based on the volume of touch-go-operations at the airport, which are only counted as one operation.
	ADS-B Receivers, RADAR, MLAT	FlightRadar24	FlightRadar24 employs receivers that capture Mode-S signals. The subscription provides live flight tracking and can capture registration, type, age, ground speed, real-time position, squawk code, altitude, airspeed, and other data. Business subscriptions provide three years of flight/aircraft history. This option is only applicable for International Air Transportation Association (IATA)-registered airports.	1) Potentially very low-cost 2) Widespread implementation 3) Provides additional flight attribute data that can be helpful towards other airport planning efforts	1) Ability to capture touch-and-go and VFR traffic is questionable 2) Not available to airports that are not registered by IATA	Equipment - Free if there is a coverage gap in the company's network Subscription - $499.99/year or free (see notes)	Airports registered in IATA with limited touch-go operations are best suited for this technology.	No published statistics available.
	ADS-B Receivers, FAA's SWIM database, MLAT (RadarBox)	AirNav	This technology depends on receivers that capture ground and satellite-based Mode-S signals. The subscription service also taps into other data sources including FAA SWIM, and MLAT. The subscription provides live flight tracking and can capture registration, type, age, ground speed, real-time position, squawk code, altitude, airspeed, etc.	1) Potentially very low-cost 2) ADS-B feed can be merged with other sources to capture aircraft not equipped with ADS-B	1) Ability to capture touch-and-go and VFR traffic is questionable	Equipment - $200 for standard ADS-B receiver, free if there is a coverage gap Subscription - $399.50/year or free	Airports with limited touch-go operations and comprehensive tracking coverage are best suited for this technology.	No published independently assessed accuracy statistics available. AirNav cites an accuracy of 99 percent.

Sources: Kimley-Horn, 2021; Various manufacturers'' websites, 2021; ACRP, 2015; FDOT, 2018

3.2.1.1. Automated Acoustics Counters

An AAC is an acoustical device that can identify and capture departing aircraft by the unique acoustic signature emitted. These counted takeoffs are multiplied by two to calculate an estimated total number of aircraft operations at the airport. Wilderness Systems and Technologies provides an AAC device to airports called the ADS 4000 Phoenix. This device costs $4,950 at the time of publishing and is advertised to be durable enough to be untouched for several months, even in below freezing temperatures. Based on information obtained during the MnSASP, the developer reported that the device is designed for small turf runways, which would imply that it is best suited for Landing Strip Turf airports in Minnesota. However, the device has difficulty recording relatively quiet aircraft such as small single-engine propeller aircraft, which are common users of Landing Strip Turf airports in Minnesota. According to a study completed by FDOT in 2018, the ADS 4000 Phoenix struggles to accurately count operations for runways longer than 5,000 feet if only one unit is installed. Difficulty in capturing touch-and-go activities was also cited by the FDOT study.

With these limitations, the ADS 4000 Phoenix is only recommended at Intermediate Small airports with shorter runways and limited touch-go operations. The developer reported that the ADS 4000 Phoenix is operating at 12 airports in Minnesota on a 24/7 basis (as of the of fall 2021). Figure 3.2 depicts an installed AAC from three perspectives.

Figure 3.2. AAC Installation

Source: Kimley-Horn, 2018

3.2.1.2. Radio Transmissions

General aviation airports can track aircraft operations through monitoring aircraft radio frequencies. G.A.R.D. records aircraft operations by counting radio transmissions registered by an airport's UNICOM station. A UNICOM station establishes radio frequencies for airports to provide flight advisories to nearby aircraft and for pilots to report their position to other aircraft. G.A.R.D. taps into an airport's UNICOM and uses automated speech recognition to identify distinct aircraft on frequency. The software is configured to review the communications on UNICOM and identify a relevant operation based on a pre-established number of transmissions that constitutes an arriving/departing aircraft. Based on device settings established by users, the device identifies arriving/departing aircraft and excludes aircraft transitioning through nearby airspace that are not conducting an airport operation. However, G.A.R.D. is not able to account for pilots transmitting on UNICOM either more or less frequently than the users-established number of transmissions. In these cases, G.A.R.D. can inaccurately count operations. Accordingly, G.A.R.D. is suitable for airports that observe consistency in pilot communication on UNICOM. According to a study completed by FDOT, the overall accuracy of the G.A.R.D. was recorded to be 85 percent, with one airport recording 91 percent accuracy (note the accuracy is highly dependent on the precision of user data parameters; namely, the number of transmissions estimated per takeoff or landing). **Figure 3.3** shows the final G.A.R.D. installation including hardware and graphical interface.

Figure 3.3. G.A.R.D. Final Installation Hardware (left) and Graphical Interface (right)

Source: Kimley-Horn, 2018

3.2.1.3. Video Imaging

Vector Airport Systems provides an operations counting device called VANTAGE that uses a combination of ground-based video imaging, RADAR, and flight plan tracking.[3] Unlike acoustical counters, the VANTAGE system can capture more details on operating aircraft by using video imaging to record aircraft registration numbers, also known as “N-numbers.” This ground-based equipment is installed on the airfield to capture N-numbers of arriving/departing aircraft, as pictured in **Figure 3.4**. Airports can also elect to pair the VANTAGE system with the Xtend product by L3Harris to incorporate the FAA NextGen data feed, enabling greater accuracy and visibility to provide more aircraft/flight details (i.e., date/time of operation, operation type, tail number, flight number, runway used, aircraft operator information). The device manufacturer reports that the VANTAGE system coupled with the Xtend product by L3Harris is 99 percent accurate in capturing aircraft operations.

[3] Vector (2021). “Vantage Automated Aircraft Identification System.” Available online at https://9c679666-ee7a-4e01-9a24-69deb1efe2b2.filesusr.com/ugd/0af77d_bb33b9c80e054b8eb279295bf23daa41.pdf (accessed August 2021).

Figure 3.4. VANTAGE Video Imaging Equipment

Source: Vector Airport Systems, 2021

The cost to purchase and implement this solution is estimated to be at least $25,000, with an additional $10,000 in annual maintenance costs. This may be prohibitive for many smaller GA airports in Minnesota with limited funding availability. As such, this system is best suited for larger GA and commercial service airports that may have greater financial resources. These airports may also more greatly benefit from the level of detail this solution provides.

3.2.1.4. Satellite Tracking

As a part of the FAA's NextGen initiative to improve the National Airspace System (NAS), ADS-B utilizes satellite tracking to capture aircraft operations more accurately and efficiently than conventional RADAR. As of January 1, 2020, all aircraft operating in airspace defined in 14 Code of Federal Regulations (CFR) Part 91.225 are required to have an ADS-B out receiver equipped. In response, several providers have emerged to leverage ADS-B to provide accurate flight tracking capabilities to airports. ADS-B tracking is typically complemented by other data sources and tracking capabilities such as the FAA's SWIM database and RADAR MLAT systems. These federal programs help to identify aircraft not yet equipped with an ADS-B out transponder to broadcast their positions. An overview of several of the largest manufacturers operating in the United States (U.S.) is provided below.

FlightAware

FlightAware owns a network of company-issued and crowdsourced ADS-B receivers in the U.S. to capture aircraft equipped with ADS-B and Mode S. The company also leverages other data sources such as FAA's SWIM, RADAR feeds, and MLAT to provide a "Hyperfeed" for airport and airspace tracking.[4] This allows the system to capture some aircraft operating under VFR or without an FAA-filed flight plan. However, FlightAware is unable to record military operations and records touch-and-go activity as one operation, rather than isolating each instance of a takeoff/landing. This can significantly undercount operations at airports that witness a large volume of flight training and military activities.

Airports can purchase historical reports of activity from FlightAware. Depending on the timeframe and airport type (i.e., activity levels), historical 12-month reports range from approximately $450 to over $4,500. Such one-time purchases can be more cost-effective for airports looking for historical snapshots on-demand. Continuous, subscription-based data services are also available.

FlightRadar24

FlightRadar24 employs a combination of data feeds including ADS-B, RADAR, and MLAT to provide real-time flight tracking. All users can view basic flight and aircraft details for each tracked operation. Paid subscribers can gain visibility to other aircraft/flight/weather details (aircraft serial number, age, vertical speed, wind conditions etc.) and up to three years of historical data.[5] The top-tier business subscription for airports provides all available information and up to three years of historical data.

The FlightRadar24 business subscription operates on a yearly subscription basis at $499.99 per year (as of fall 2021). However, if an airport is willing to install a complimentary ADS-B receiver and make the data publicly available, the yearly fee is waived. While FlightAware may provide the most cost-effective solution for some airports, the technology is still limited in its ability to capture touch-and-go and VFR operations. As such, FlightRadar24 may not be appropriate for all airports.

AirNav RadarBox

AirNav's RadarBox provides real-time flight tracking using a combination of 12 different data feeds, including ADS-B, FAA's SWIM, and MLAT. With the free basic access, all users can view basic aircraft and flight details (aircraft type, altitude, location, arrival/departure airport, serial number). Like FlightRadar24, paid subscribers have access to additional aircraft, flight, and weather details (ground speed, vertical speed, aircraft age, weather RADAR layers) and can pull more than a week's worth of historical flight data. The business subscription provides all available flight data for up to a year's worth of historical flights collected by RadarBox.

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[4] FlightAware (2021). "FlightAware's Data Sources." Available online at https://flightaware.com/about/datasources/ (accessed November 2021).

[5] FlightRadar24 AB (2021). "Subscription Plans." Available online at https://www.flightradar24.com/premium?utm_source=website&utm_medium=nav&utm_campaign=menu_subs (accessed November 2021).

RadarBox's business subscription is available on a monthly ($39.95 per month) or yearly subscription basis ($399.50 yearly). AirNav provides and installs an ADS-B receiver at airports able to fill a gap in its flight tracking coverage free of charge. Additionally, the business subscription cost is waived if the airport elects to make the data public. With the undercounting associated with touch-and-go operations, RadarBox is best suited for airports with limited flight training or military activities.

3.2.2. OPERATIONS AT MINNESOTA'S NON-TOWERED GA AIRPORTS

As highlighted by the previous section, non-towered airports have several potential options to capture operational activity. Alternatives vary in accuracy, data limitations, cost, ability to access historical details, data process requirements, and other variables. In some cases, airports may opt to visually survey takeoffs and landings. A staff member or volunteer can manually report operations during different time periods of the year (e.g., winter, summer, special events). Collected data can then be extrapolated to estimate annual operations. Well-designed surveys that account for factors including seasonality and special events can provide high-quality results sufficient for planning-level activities at many airports.

In addition to the operations counting strategies deployed at the individual airport level, the FAA's Operations & Performance Database comprises several systems that record historical aircraft operations, aviation forecasts, and delay statistics nationally (reported by airport). The Operations Network (OpsNet) is the FAA's official source for air traffic operations. OpsNet continuously captures operations data for airports with an ATCT (or towered airports).[6] The FAA also manages the Traffic Flow Management System Count (TFMSC) data repository. The TFMSC records flights conducted under Instrument Flight Rules (IFR), for which flight plans were filed with the FAA, and when some en route flights are detected in the NAS. The TFMSC is typically considered the most complete dataset of aircraft operations in the U.S., with over 97 percent accuracy at the nation's busiest airports. However, the TFMSC is insufficient for obtaining data about many GA airports because flights conducted under VFR are generally excluded. OpsNet only captures data from ATCTs. Both the TFMSC and OpsNet are critical in understanding activity with the NAS despite these limitations. Additionally, the FAA maintains 5010 Airport Master Records for all airports in the U.S. 5010 Airport Master Records include operations by type (e.g., air carrier, air taxi, military, GA local, GA itinerant, etc.). However, data are reported by airport managers/sponsors without validation. Data may significantly under- or over-report activity that are actually occurring.

The goal of the 2022 MnSASP was to develop a strategy to overcome the data limitations of OpsNet and the TFMSC while adding a layer of validity and accuracy to data in the 5010 Airport Master Record. The resulting approach couples federal and local 5010 data to provide a recommended methodology to estimate operations at non-towered GA airports in Minnesota. Airport sponsors and planning consultants are encouraged to consider using these baseline counts in their own planning efforts unless actual data are captured via an operations counting technology, survey, or other validated process.

While MnDOT Aeronautics acknowledges that the results obtained from this effort are based on extrapolation, they provide uniformity, transparency, and standardization in how they were obtained. Airport operations estimates developed in the MnSASP are used to aggregate operations for system planning. Individual airport information shall not be used independently for establishing an airport's

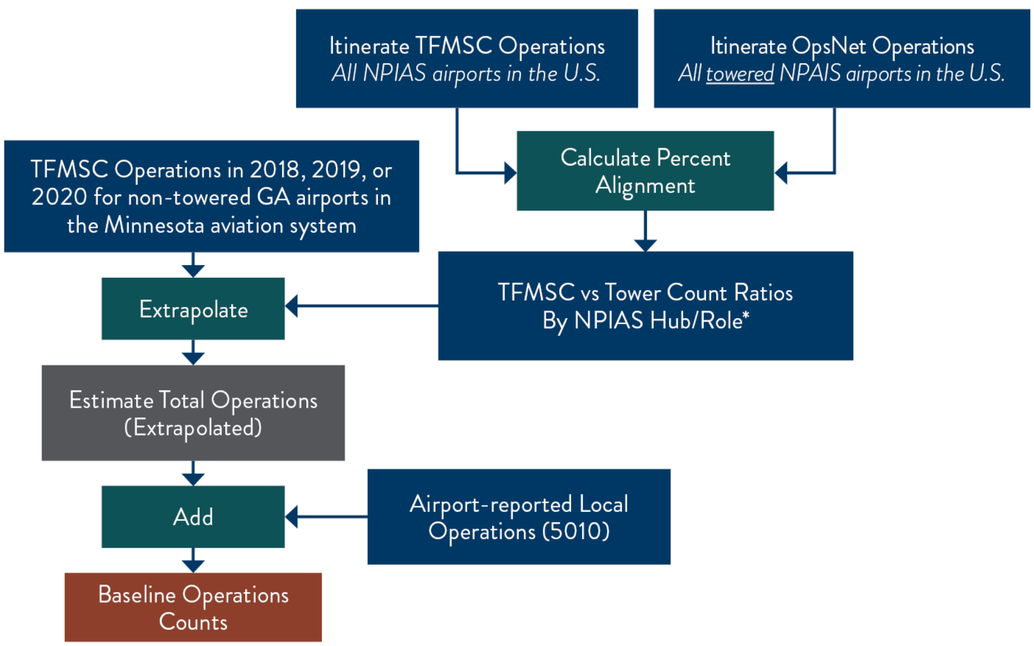
[6] Note it is acknowledged that many ATCTs do not operation 24 hours a day, 7 days a week (24/7). However, this analysis assumes that towers provide the most accurate source of data available and do capture most operations occurring at an airport.

forecast and/or funding decisions. Airport sponsors should coordinate with their assigned MnDOT Aviation Planner and the FAA (National Plan of Integrated Airport Systems [NPIAS] airports only) prior to beginning any forecasting effort to confirm the suitability of baseline operations employed in an airport-specific analyses.

3.2.2.1. Methodology

The 2022 MnSASP leveraged federal databases combined with airport-specific estimates to generate a standard methodology for obtaining baseline operations for Minnesota's non-towered GA airports. In summary, the MnSASP employed OpsNet and the TFMSC to estimate operations conducted via IFR at non-towered, GA Minnesota system airports, then added local operations reported on each airport's 5010 Airport Master Record (assumed to fly using VFR). Figure 3.5 summarizes the 2022 MnSASP methodology.

Figure 3.5. MnSASP Baseline Annual Operations Methodology Process



**Note: Non-NPIAS airports applied the nationwide TFMSC vs OpsNet percent alignment for Local/Basic airports.*
Source: Kimley-Horn, 2021

As the first step in the Minnesota operations counting methodology, the percentage between itinerant traffic captured by OpsNet versus reported in the TFMSC was calculated for all towered airports in the U.S. While OpsNet generally provides the most accurate data available, activity occurring when an ATCT is closed is not captured. A portion of operations conducted when the tower is closed would be reported in the TFMSC but not in OpsNet. Only itinerant traffic was considered in the TFMSC versus OpsNet alignment to prevent duplication with adding airport-reported local operations from the 5010 (the last step of the operations counting methodology as illustrated in Figure 3.5). The itinerant TFMSC versus itinerant OpsNet alignment percentages were calculated by Nonprimary NPIAS role (i.e., National, Regional, Local, Basic, Unclassified). Due to the low sample size of towered Local and Basic airports nationwide (14 and 2, respectively), the TFMSC versus OpsNet alignment percentages were combined for both roles to create a "Local/Basic" average of itinerant TFMSC versus itinerant OpsNet percentage alignment.

It was determined that the itinerant OpsNet versus itinerant TFMSC percent alignment by Nonprimary Role provided the most granularity and were therefore carried forward in the analysis. Additionally, calculating the percentages can be replicated to determine baseline operations in future years for system planning purposes. Percentages were calculated for 2018, 2019, and 2020 (the reason for which is explained in the following steps). **Table 3.2** presents the TFMSC versus OpsNet percent alignments applied in the methodology. At National facilities, the number of operations reported in TFMSC is approximately 34 percent of those reported in OpsNet. This means that 34 percent of operations reported in the TFMSC were also reported in OpsNet. However, that percent alignment generally decreases as airports become smaller, with GA – Local/Basic airports reporting a correlation of approximately 15 percent. This is not surprising, as smaller airports generally do not have an active ATCT. Further evaluation is warranted to understand the various factors that could be impacting the percent of operations reported in the TFMSC versus OpsNet, as well as the potential implications for planning efforts that rely on the data being reported in the two repositories.

Table 3.2. Itinerant OpsNet versus Itinerant TFMSC Percent Alignment by Nonprimary Role

NPIAS Role	No. of Airports	TFMSC VS OPSNET Alignment – 2018	TFMSC VS OPSNET Alignment - 2019	TFMSC VS OPSNET Alignment - 2020
GA - National	75	38.2%	37.2%	34.2%
GA - Regional	123	18.4%	17.9%	17.1%
GA – Local/Basic	16	16.4%	15.3%	14.5%
GA – Unclassified*	1	42.6%	49.9%	46.1%

**Note: There is one Unclassified non-towered airport in the U.S. The results of this percent alignment were not employed during subsequent steps of the methodology due to the sample size. Sources: FAA OpsNet (accessed May 2021); FAA TFMSC (accessed May 2021); Kimley-Horn, 2021*

The percentages presented in **Table 3.2** were then multiplied by total operations by airport reported in the TFMSC for all non-towered airports in the Minnesota state aviation system. The percentage for GA – Local/Basic airports was applied to non-NPIAS facilities.[7] The percentage year varied because the results of this analysis were added to local operations reported in 5010 Airport Master Records (as will be discussed in the next step). 5010 Airport Safety Inspections typically occur on a three-year cycle which ranged from 2018 to 2020 at the time of analysis.[8] The 2022 MnSASP planning team felt it was important to maintain consistency between the percent alignment year, airport-specific data from the TFMSC, and the airport's latest 5010 Airport Master Record.

This extrapolation resulted in the estimated GA itinerant and military traffic. Airport-reported local operations from the 5010 Airport Master Record were then added. Per the FAA, local operations are defined as operations performed by an aircraft that remain in the local traffic pattern, execute simulated

[7] While there is one Unclassified towered airport in the U.S., this sample size is insufficient to provide confidence in the results.
[8] Slayton Municipal Airport (DVP) was the only airport with 5010 Airport Master Record dating from 2017. Data years are different because 5010 Airport Safety Inspections are completed on a three-year cycle for airports without air carrier service.

instrument approaches or low passes at the airport, and operations to or from the same airport within a designated practice area within a 20-miles radius of the tower.[9] It was determined that the initial extrapolated results under-reported local traffic flying under VFR, and that airport managers could provide the most accurate estimation of this type of activity. The FAA publishes the airport's local operations in the 5010 Airport Master Record on a three-year cycle, accessible through the FAA's Airport Data and Information Portal (ADIP). As this data is updated regularly, easily accessible through ADIP, and could provide the most accurate estimates of local operations, the MnSASP incorporated these counts into the baseline annual operations methodology. It is understood that local operations published in the 5010 Airport Master Record may be estimates provided by the airport manager with little validation. However, as discussed at the beginning of **Section 3.2**, it is difficult to count operations at nontowered airports. MnDOT Aeronautics recommends that airports consider the operations counting technologies described in **Section 3.2.1** to capture more robust and accurate baseline operations.

Local operations were obtained based on the airport's current (at the time of the analysis in May 2021) 5010 Airport Master Record, nearly all of which ranged from 2018 to 2020.[10] Extrapolated plus airport-reported local operations provide the baseline operations counts for non-towered GA airports in Minnesota. The equation is summarized as follows:

TFMSC x TFMSC vs OpsNet Ratio + 5010 GA Local Operations =
Extrapolated Baseline Operations at Non-towered GA Airports

OpsNet data (2019) was obtained for towered GA airports and carried forward into the forecasting task. A 2019 base year was selected because it was the most recent full year of data available when the analysis was conducted. Additionally, flight activity in 2020 was significantly impacted by COVID-19. The year 2020 did not provide an accurate representation of activity occurring in a typical year.

3.2.2.2. Results

Table 3.3 presents the aggregated total baseline operation counts generated from the Excel-based annual operations estimation tool for all GA airports in the Minnesota state aviation system. These extrapolated counts were compared with the airport-reported annual operations collected in triennial 5010 Airport Safety Inspections as reported on the 5010 Airport Master Records. Extrapolated baseline operations at all non-towered GA airports are estimated to be four percent higher than data recorded in the FAA's 5010 Airport Master Record. Extrapolated baseline operations at Minnesota's largest GA airports (Key GA) are 7 percent lower, indicating that these airports may be over-reporting operations. Intermediate Large, Intermediate Small, and Landing Strip Turf airports also have a similar comparison, indicating that airports statewide may be over-reporting operations. Extrapolated baseline operations at all 124 GA airports are 18 percent lower than reported in 5010 Airport Master Records. Airport-specific baseline operations counts are provided in **Table A.1** in **Appendix A. Operations Counting and Forecasting Tables.**

[9] Federal Aviation Administration (2023). "OPSNET Reports: Definitions of Variables" Available online at https://aspm.faa.gov/aspmhelp/index/OPSNET_Reports__Definitions_of_Variables.html (accessed January 2023).
[10] Ibid.

Table 3.3. Baseline Operation Counts by State Classification

State Classification	Number of airports	Total 5010 operations*	MnSASP Extrapolated baseline operations	Percentage difference
Key GA	22	623,166	577,466	-7%
Intermediate Large	36	437,000	347,341	-21%
Intermediate Small	46	402,674	296,714	-26%
Landing Strip Turf	20	69,157	41,458	-40%
Total	123	1,531,997	1,262,979	-18%

**Note: 5010 data reflect the most current available at the time of analysis in May 2021. Table A.1 in Appendix A indicates the data year for each airport. Sources: Kimley-Horn, 2021; FAA 5010 Master Record (accessed October 2021); FAA TFMSC (accessed May 2021); FAA's OpsNet (accessed May 2021)*

3.3. Forecasts of Aircraft Operations

Baseline operations calculated using the Minnesota-specific ops counting methodology described in Section 3.2.2 were carried forward into the MnSASP forecasting effort. The scope of this task encompasses operations at the state's 124 GA airports. Commercial service airports generally develop detailed forecasts as part of their own planning efforts. It should be noted that the MnSASP forecasting effort does not replace airport-specific forecasting efforts completed during master planning and published in the FAA's Terminal Area Forecasts (TAF).

Many factors inherent to and external from the aviation industry may impact future operations in Minnesota. This includes statewide, national, global trends associated with the economy; traveler behavior; regulatory requirements; and a host of other variables that affect how, why, and when people take to the skies. At the time of this writing in early 2022, the world continues to deal with the uncertainty associated with the ongoing impacts of COVID-19, although vaccines are now widely available in the U.S. While the pandemic has primarily impacted scheduled commercial service activities, the potential for new variants remains a threat. Interestingly, COVID-19 has correlated with a rise in GA activities for a variety of reasons. When asked about this issue during the MnSASP data inventory in spring 2021, GA airport managers nearly ubiquitously reported a rise in activity levels and fuel sales during the height of the pandemic. Any new COVID-related development could precipitate a rise or decline in activity based on geography, airport type, activity indicator (GA, commercial enplanements, air cargo tonnage, etc.), and other factors.

With the ongoing backdrop of COVID-19, the U.S. is facing inflation, a labor shortage, supply chain issues, and general economic uncertainty. The cost of crude oil is rising in many places in the world, including the U.S. Geopolitical unrest impends eastern Europe, with impacts that could threaten energy exports throughout the region. Closer to home, Minnesota's population is moving away from rural agricultural areas to urban centers. Such migration may shift demands on airports that provide the recreational, commercial, and quality-of-life benefits upon which nearby residents, businesses, and visitors rely.

Within the aviation industry, the small piston-powered GA fleet continues to shrink while demand for larger GA aircraft, including jets and rotorcraft, rises. The FAA and U.S. Environmental Protection Agency

(EPA) stress the health and environmental concerns associated with 100 low lead (100LL), which remains the only lead-containing fuel in the U.S. The U.S. Congress and these agencies have discussed banning 100LL although a viable alternative has not yet been identified. New aviation technologies such as electric aircraft with vertical/short takeoff and landing capabilities (eVTOL/eSTOL), are moving closer to commercial deployment. These technologies may make flight cheaper, greener, and more accessible than ever before. At the same time, traditional revenue streams (e.g., fuel flowage fees) could diminish while facility needs increase (e.g., hangar storage capacity, ramp space, electric charging stations).

In short, future aviation activities are uncertain, and year-over-year demand variations are expected. However, the MnSASP forecasts were developed in consideration of historic trends and projected future activities associated with socioeconomic conditions and national aviation projections. They are assumed to present an accurate view of future activities over the mid- and long-terms. Demand projections have been developed through 2040 at five-year increments (2025, 2030, 2035, 2040).

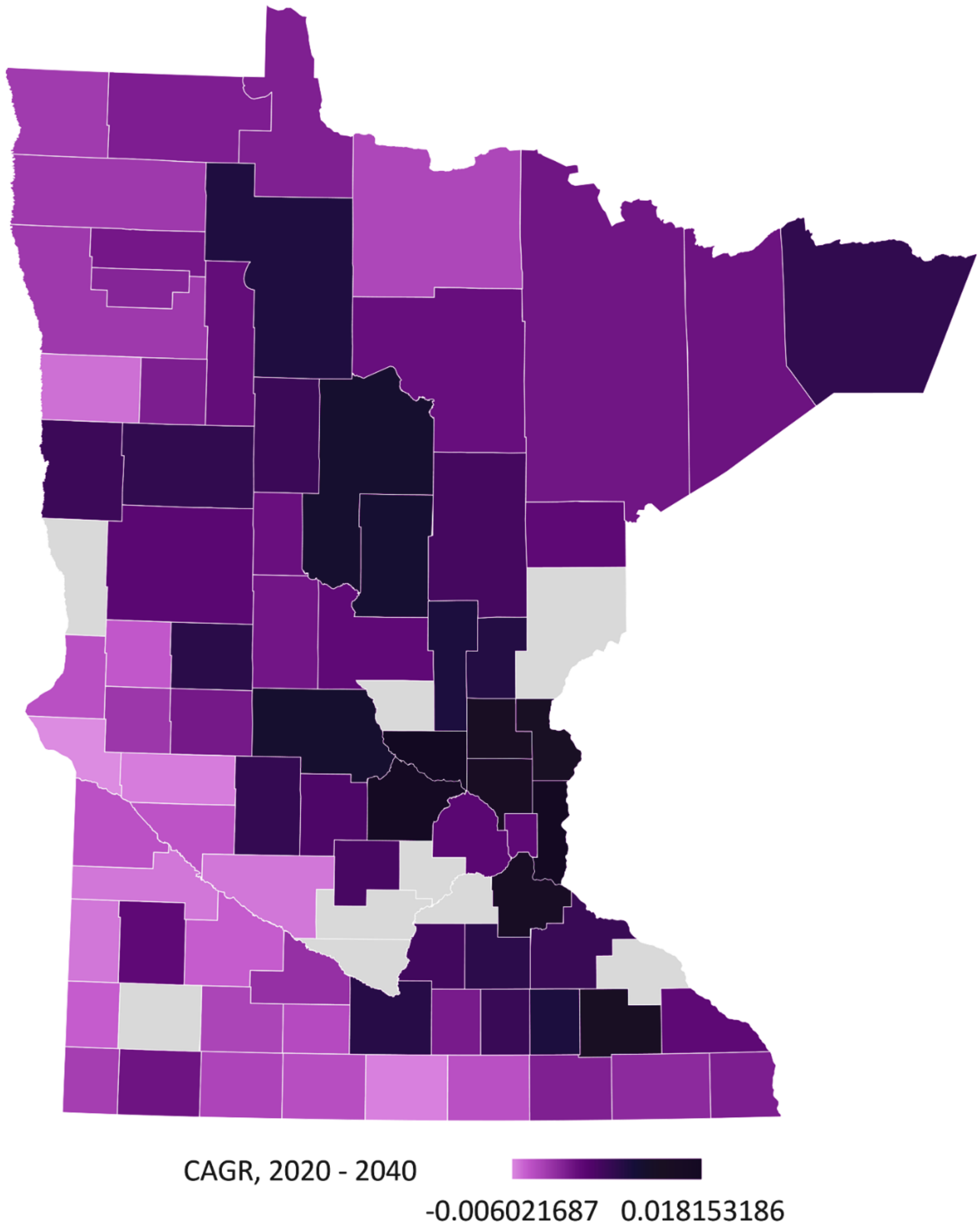
Four methodologies were evaluated to forecast civilian operations at each of Minnesota's 124 GA airports. Military activities were excluded because they are driven by federal policies and global forces and cannot be projected using GA methodologies. The MnSASP GA forecast methodologies looked at county-specific socioeconomic factors (population and per capita personal income [PCPI]) and national GA trends (flight hours flown). A methodology was also evaluated that blended the two socioeconomic factors (population and PCPI) and GA hours flown to account for the combined impacts of all variables. Based on discussions with MnDOT Aeronautics and the FAA, it was determined that methodologies should be selected by state classification to most effectively align drivers of aviation activity with future operations. As such, a "Mixed Methodology" is also presented. The Mixed Methodology is the preferred methodology of the 2022 MnSASP. A summary of each methodology is provided below, with airport-specific results presented in **Tables A.2 through A.7** in **Appendix A**.

3.3.1. SOCIOECONOMIC – POPULATION GROWTH BY COUNTY

Socioeconomic projections can be a useful indicator of future airport activity. The population living around GA airports typically represents its primary user base. Residents may also attract commercial, non-military government, other supporting aviation activities such as air cargo and medical air flying. As such, population growth may predicate an increase in operations occurring at an airport. This methodology assumes that GA operations are correlated with the projected population growth of the county in which each airport is located. County-specific population forecasts were obtained from Woods & Poole (W&P) for the 20-year planning horizon. Population growth rates were applied to the baseline operations counts, projecting each airport's operations through 2040. The same growth rates are applied to airports located in the same county.

As **Figure 3.6** shows, Minnesota's fast-growing counties in terms of population are projected to be Sherburne (1.82 percent compound annual growth rate [CAGR]), Washington (1.79 percent CAGR), and Wright (1.72 percent CAGR) counties. Twenty-six counties primarily located in southwest Minnesota are projected to lose population through the planning horizon. This aligns with the ongoing general trend of urbanization occurring in many U.S. states including Minnesota. The counties depicted in beige do not have state system airports.

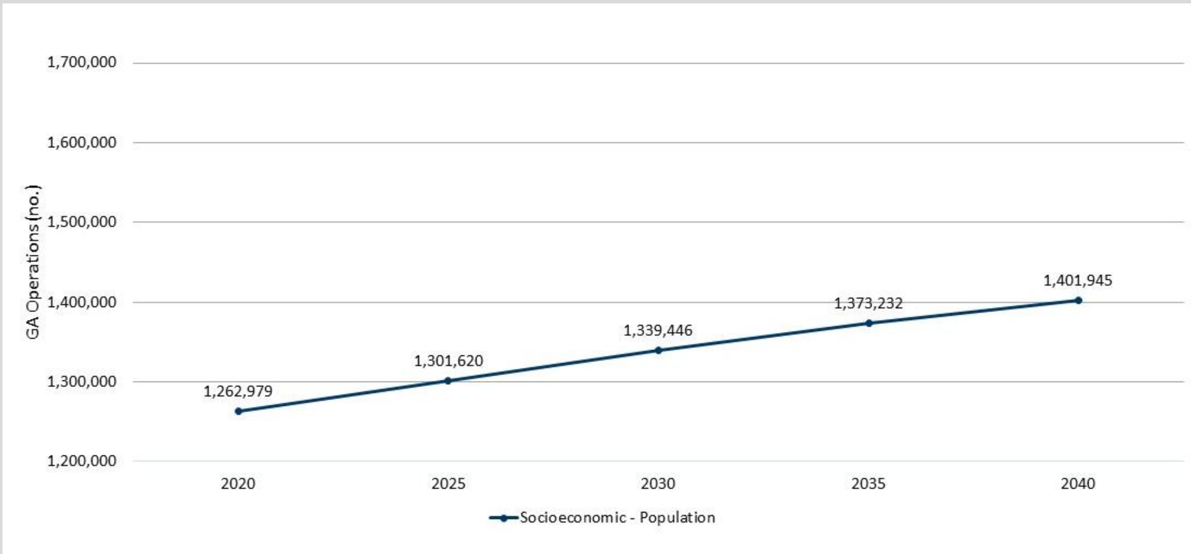
Figure 3.6. Population Growth Rates by Minnesota County, 2020 – 2040



Note: The counties depicted in beige do not have a state system airport. Source: W&P, 2021

The results of this analysis shown an increase from 1,262,979 baseline operations in 2020 to 1,401,945 by 2040, resulting in a 0.52 percent CAGR. This is the lowest growth rate evaluated as part of the MnSASP forecasting task. Individual airport results are included in Table A.2 in Appendix A.

Figure 3.7. MnSASP GA Methodology 1: Socioeconomic – Population Growth by County



Sources: W&P, 2021; Kimley-Horn, 2022

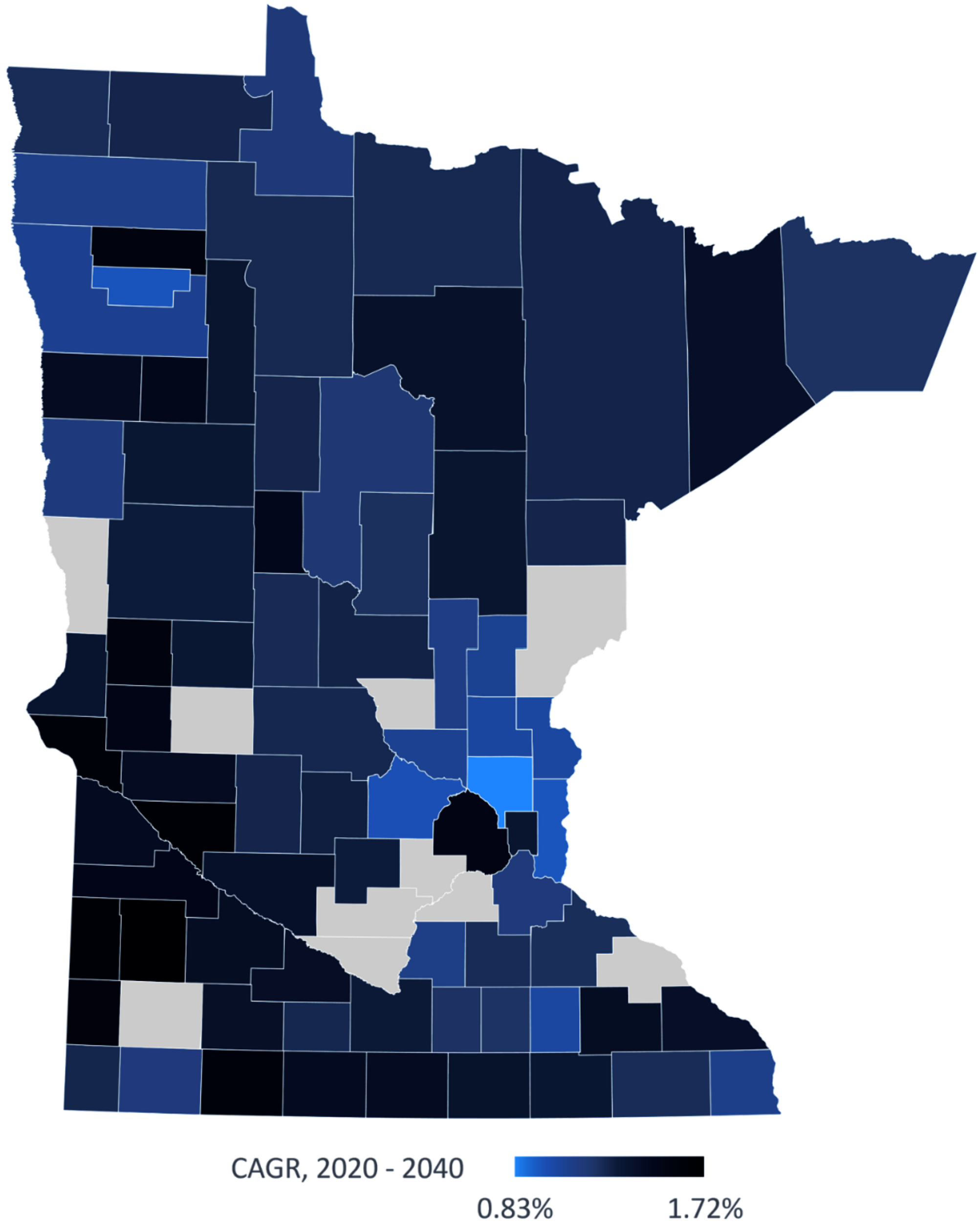
3.3.2. PCPI GROWTH RATES BY COUNTY

Projected income growth can also be an indicator of future airport activity. Engaging in some types of GA activities such as recreational flying and flight training is expensive for users. As such, there can be a correlation drawn between GA operations and PCPI. However, this methodology does not always adequately account for critical GA activities that are independent of the income of nearby residents. For example, aerial spraying, medical air flying, and government activities are all supported by GA facilities but not tied to PCPI.

This methodology assumes that airport activity is correlated with the projected PCPI growth of the county that each airport is located in. County-specific PCPI forecasts were collected from W&P for the 20-year planning horizon. Annual growth rates were applied to baseline operations counts by airport. Like the Population Growth Rates by County, airports in the same county are projected to grow at the same rate.

Figure 3.8 shows PCPI growth by Minnesota county between 2020 and 2040. All counties are anticipated to experience a rise in PCPI through the forecast horizon between 0.83 and 1.72 percent. Counties depicted in dark green are projected to experience the most significant percent growth rate. As depicted, income is generally rising most steeply in southwestern Minnesota, with Lyon, Lincoln, and Chippewa counties experiencing the highest CAGRs (1.72 percent, 1.56 percent, and 1.56 percent CAGRs, respectively). This is interesting because counties in this same region are anticipated to most rapidly lose population through 2040.

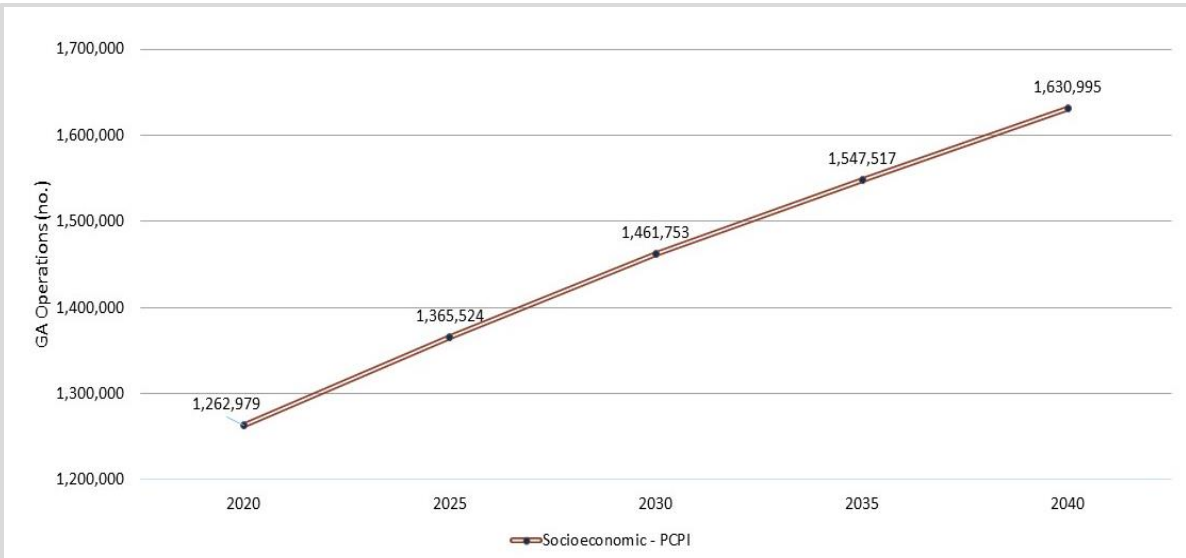
Figure 3.8. PCPI Growth by MN County, 2020 – 2040



Note: The counties depicted in beige do not have a state system airport. Source: W&P, 2021

The results of this analysis show that GA operations in Minnesota will increase from 1,262,979 in 2020 to 1,630,995 by 2040 for a CAGR of 1.29 percent (see Figure 3.9). This methodology projects the highest growth rate of all alternatives evaluated by the MnSASP. Individual airport results are included in Table A.3 in Appendix A.

Figure 3.9. MnSASP GA Methodology: Socioeconomic – PCPI



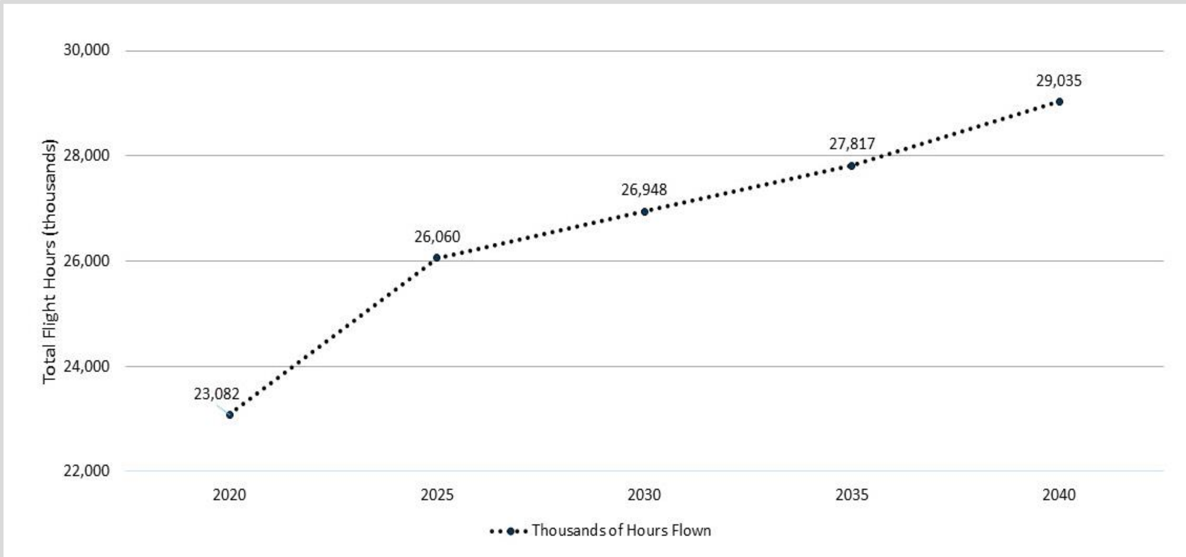
Sources: W&P, 2021; Kimley-Horn, 2022

3.3.3. U.S. TOTAL GA FLIGHT HOUR GROWTH RATES

The number of hours GA aircraft are flying in the NAS is an important indicator of demand on the system. Flight hours flown likely gauge capacity needs better than based aircraft, as some GA aircraft rarely. The FAA forecasts GA flight hours flown at a national scale as reported in the biennial Aerospace Forecasts. Forecast rates for the MnSASP were obtained from the *FAA Aerospace Forecasts, Fiscal Years 2021 - 2041 (Aerospace Forecasts 2021 - 2041*), which was the most current report available at the time of analysis. The *Aerospace Forecasts 2021 - 2041* project a higher annual growth rate in the near-term, with the pace of growth slowing in the mid-term. It is important to note that the FAA anticipates that growth in GA activity will be driven by the more sophisticated turbine-powered fleet (including rotorcraft) due in part to corporate flying. The fixed-wing piston-powered fleet may decline due to aging private pilots, the cost of aircraft ownership, and the availability of lost-cost alternative for recreational usage. According, the light sport aircraft category is predicted to grow through the forecast horizon, with the total fleet size expected to nearly double by 2040 based on the 2018 fleet.

Figure 3.10 shows the projected total number of hours flown by the total U.S. GA fleet. Between 2020 and 2040, hours flown are forecast to increase from 26,039 to 30,205 for a CAGR of 0.7 percent.

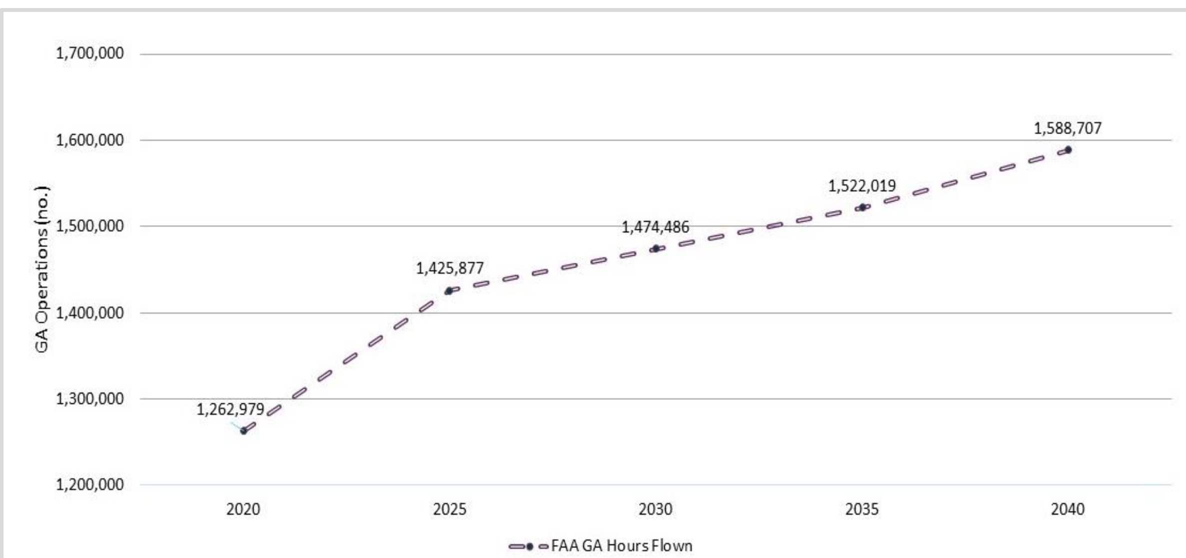
Figure 3.10. Projected U.S. GA Flight Hours Flown, 2020 – 2040



Source: FAA Aerospace Forecasts, 2021 - 2041

This methodology produces a growth rate of 1.15 percent in GA operations in Minnesota through the forecast period. As shown in Figure 3.11, total statewide operations are projected to reach 1,588,707 by 2040. Individual airport results are included in Table A.4 in Appendix A.

Figure 3.11. MnSASP GA Methodology: GA Flight Hours Flown



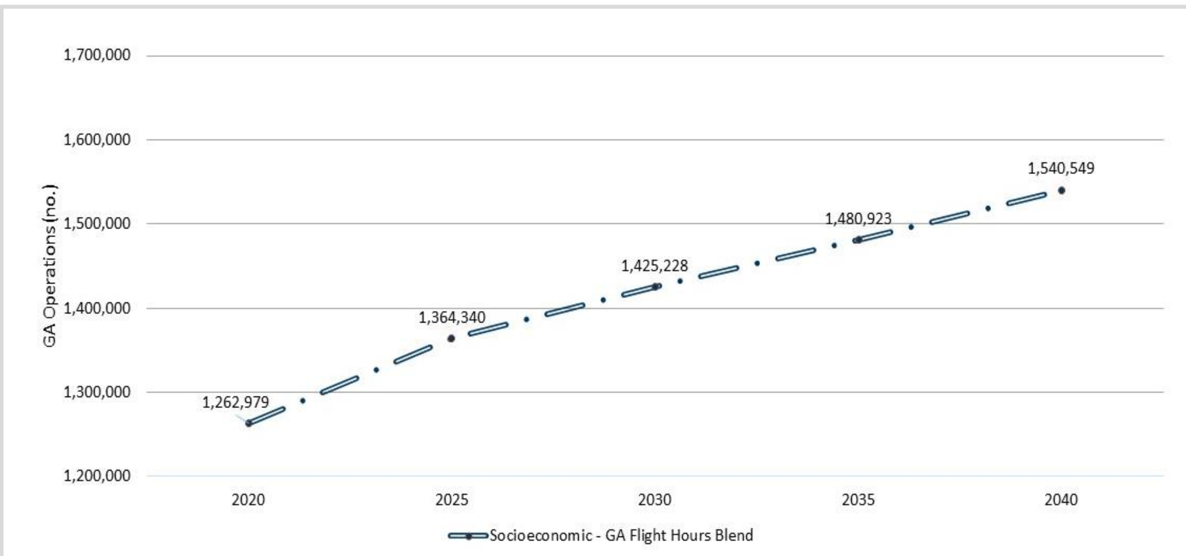
Sources: FAA Aerospace Forecasts, 2021 - 2041; Kimley-Horn, 2022

3.3.4. SOCIOECONOMIC – GA FLIGHT HOURS BLEND

Each of the variables considered in the methodologies discussed above provide insight into one driver of GA activity in Minnesota. As these various methodologies imply, the reasons people choose to fly as opposed to another mode of transportation are based on many factors including but not limited to required travel time, distance between origin and destination, reliability, modal preferences, cost, safety, and security. This methodology is designed to capture, in part, the complexity of aviation demand drivers by blending the aviation growth rates applied in the three previous methodologies.

This methodology yields a CAGR of 1.00 percent, representing an average of the two socioeconomic and one aviation-specific (i.e., GA hours flown) growth rates reported above. Statewide operations would increase from 1,262,979 in 2020 to 1,540,549 by 2040. Individual airport results are included in Table A.5 in Appendix A.

Figure 3.12. MnSASP GA Methodology: Socioeconomic – GA Flight Hours Blend



Sources: W&P, 2021; FAA Aerospace Forecasts, 2021 - 2041; Kimley-Horn, 2022

3.3.5. MIXED METHODOLOGY (PREFERRED)

As noted above, aviation demand is driven by a variety of factors. These factors are not the same for all airports. Indeed, the extent to which local socioeconomic factors, broader aviation trends, and other potential influences significantly differs between facilities. Current and future activities are highly influenced by the type of aviation activities typically supported by an airport. For example, a large corporation that depends on business aviation would affect an airport that primarily supports flight training quite different than one with the facilities and services to support business jets should that corporation locate nearby. Demand at the first airport, which typically witnesses a high amount of flight training, may not be impacted at all. Conversely, the second airport, which primarily supports business aviation, would likely witness an uptick in demand.

As this example highlights, the function(s) and facilities/services associated with individual airports play a vital role in understanding how factors of demand impact future activity.

Considering airport-specific demand drivers is a key task of airport master planning and generally outside of the scope of aviation system planning. However, a system plan can identify demand drivers affecting groupings of airports to add a layer of granularity into the analysis. Minnesota system airports are categorized into state classifications.[11] State classifications are defined by Part 139 certification status, runway length, and surface type (i.e., paved versus turf). As such, they provide insight into the types of aviation activities typically supported at those facilities and ergo key drivers of future activity. Accordingly, the MnSASP matched forecast methodologies with state classifications based on the demand drivers most likely to predict future activities. The proposed forecast methodology by classification, as well as the reasoning for each selection, is summarized in **Table 3.4**. This methodology is referred to as the "Mixed Methodology."

Table 3.4. Preferred Methodology by State Classification

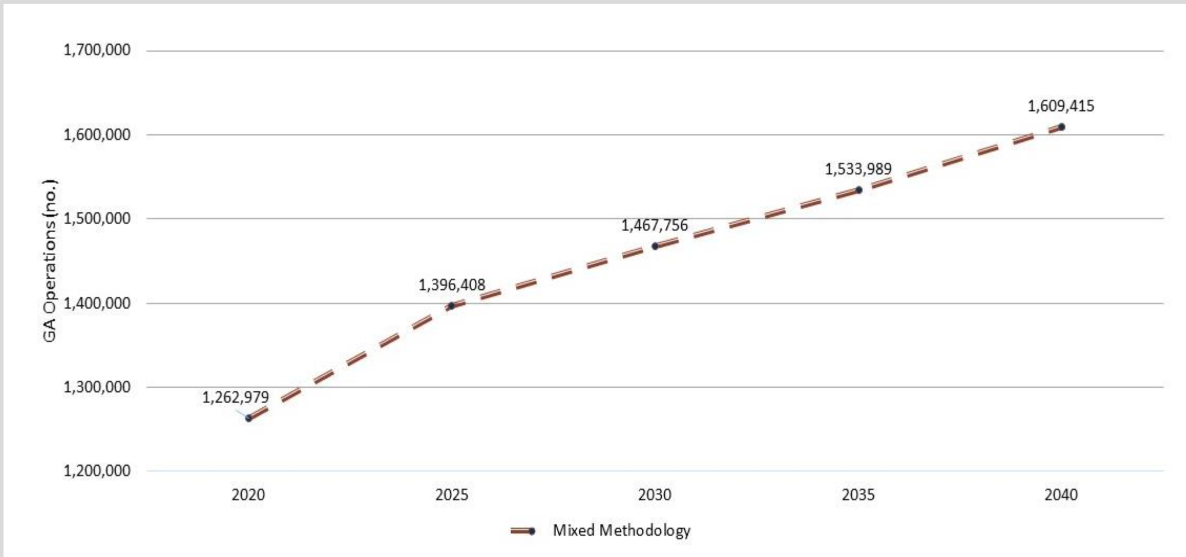
State Airport Classification	Forecast Methodology	Relevancy
Key GA	PCPI	With their longer runways, Key GA airports can support larger and/or more sophisticated aircraft typical of corporate and other demanding aviation activities. Because of the cost of operating such aircraft, it is assumed that PCPI would most likely correlate with projected demand.
Intermediate Large	GA Hours Flown	Intermediate Large and Small airports generally support recreational flying and flight training. Therefore, growth at Intermediate airports is most fundamentally driven by changes to the aviation industry itself. The FAA specifically looks at potential factors impacting these sectors when it developed that *FAA Aerospace Forecasts*. As such, it is assumed that GA Hours Flown would most effectively indicate change over time.
Intermediate Small	GA Hours Flown	See relevancy above (same as Intermediate Large).
Landing Strip Turf	Socioeconomic – GA Flight Hours Flown Blend	Activity at Landing Strip Turf airports is primarily driven by recreational flying and agricultural spraying. These diverse activities are principally correlated with nearby economic activities and local demographics. As such, the Socioeconomic – GA Flight Hours Flown Blend was selected as the most appropriate methodology to apply to future growth.

Source: Kimley-Horn, 2022

The Mixed Methodology projects a combined statewide growth rate of 1.22 percent over the planning horizon. GA operations would increase from 1,262,979 in 2020 to 1,609,415 by 2040. This equates to an additional 346,436 takeoffs and landings at Minnesota's GA airports over the next two decades. Statewide results of the Mixed Methodology are presented in **Figure 3.13**, within individual airport results included in **Table A.6** in **Appendix A**.

[11] *The classification of Minnesota's system airports is presented in Task 3: Validation of Phase I deliverables.*

Figure 3.13. MnSASP GA Methodology: Mixed Methodology



Sources: W&P, 2021; FAA Aerospace Forecasts, 2021 - 2041; Kimley-Horn, 2022

3.3.6. FORECAST METHODOLOGY EVALUATION RESULTS

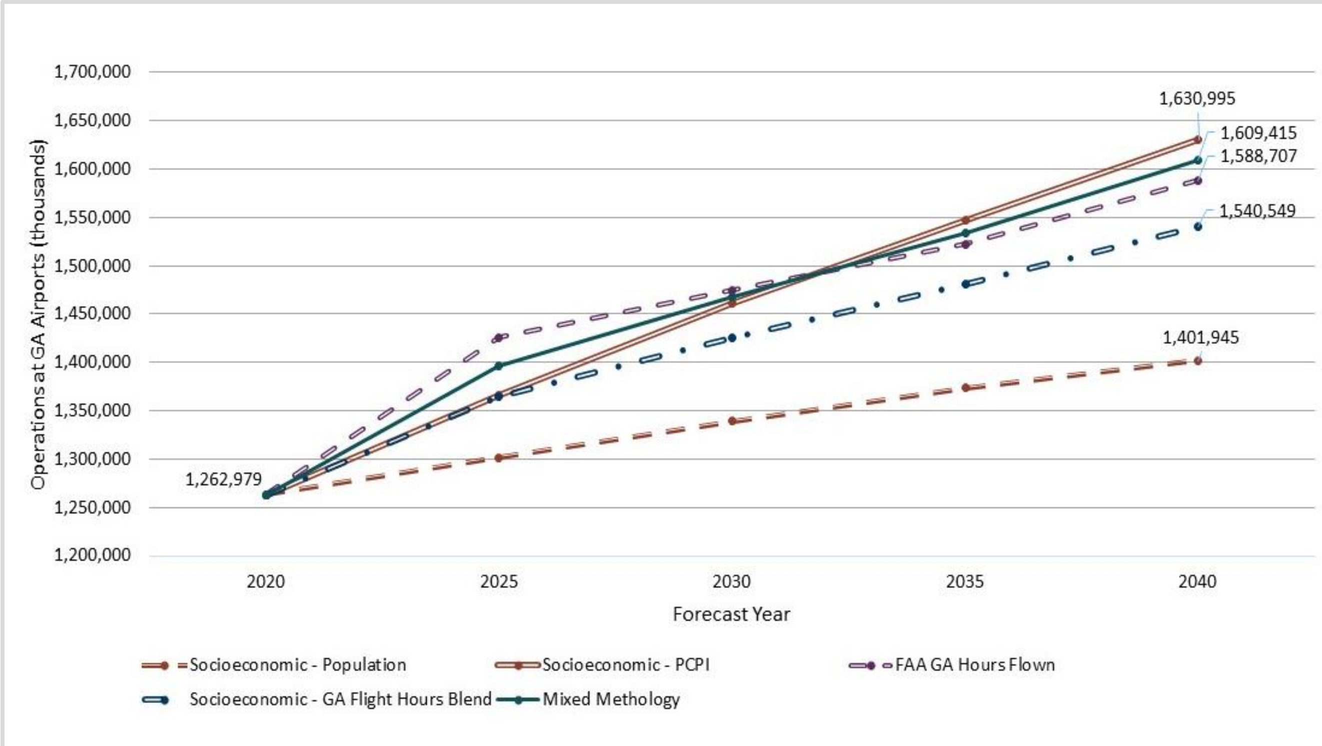
Summarized in Table 3.5, the five methodologies evaluated by the MnSASP indicate that GA operations at Minnesota's 124 GA airports may annually increase between 0.52 percent (Socioeconomic – Population Growth by County) and 1.29 percent (Socioeconomic – PCPI). Should this occur, 2022 MnSASP airports would support between 138,966 to 368,016 additional takeoffs and landings over the next two decades. Based on discussions with the FAA, MnDOT Aeronautics, and the Operations Counting and Forecasting Focus Area Working Group, the Mixed Methodology was ultimately selected as the preferred methodology of the 2022 MnSASP. This methodology most effectively accounts for the unique roles that system airports play within their communities and regions while producing a reasonable projection of growth through 2040 (1.22 percent CAGR). The preferred Mixed Methodology is shaded in dark grey in the table below. A summary of all evaluated methodologies is presented in Figure 3.14.

Table 3.5. MnSASP GA Operations Forecast Statewide Summary by Methodology

Methodology	2020	2025	2030	2035	2040	CAGR (%)
Socioeconomic – Population	1,262,979	1,301,620	1,339,446	1,373,232	1,401,945	0.52%
Socioeconomic – PCPI	1,262,979	1,365,524	1,461,753	1,547,517	1,630,995	1.29%
FAA GA Hours Flown	1,262,979	1,425,877	1,474,486	1,522,019	1,588,707	1.15%
Socioeconomic – GA Flight Hours Blend	1,262,979	1,364,340	1,425,228	1,480,923	1,540,549	1.00%
Mixed Methodology	**1,262,979**	**1,396,408**	**1,467,756**	**1,533,989**	**1,609,415**	**1.22%**

Sources: W&P, 2021; FAA Aerospace Forecasts 2021 – 2041; Kimley-Horn, 2022

Figure 3.14. MnSASP GA Operations Forecast Statewide Summary by Methodology



Sources: W&P, 2021; FAA Aerospace Forecasts 2021 – 2041; Kimley-Horn, 2022

3.3.7. COMPARISON WITH THE TERMINAL AREA FORECAST (TAF)

The FAA prepares the TAF to assist with the budget and planning needs of the agency, including demands on the NAS and airspace controllers. The TAF prepares airport-specific forecasts for busiest commercial service airports in the U.S. and detailed forecast models incorporating industry trends for all airports in the NPIAS. Advisory Circular (AC) 150-5070 (change 1), *The Airport System Planning Process*, indicates that state system plan forecasts should be compared with the TAF to ensure reasonableness.

A comparison of the baseline operations and forecasted operations at the 87 Minnesota GA airports in the TAF is provided in Table 3.6. The TAF projects that operations at these facilities will increase by 0.65 percent CAGR through 2040, while the MnSASP's preferred Mixed Methodology projects an increase of 1.23 percent CAGR during this same period. Additionally, the TAF and MnSASP evaluate a different number of baseline operations (1,134,615 in the MnSASP versus 1,347,805 in the TAF for a -15.82 percent difference). As a result of the differing growth rates and baseline operations, the disparity between the projected number of GA operations in the TAF versus the MnSASP shrinks over time. By 2040, a difference of 5.50 percent (84,372 operations) is anticipated between the two methodologies.

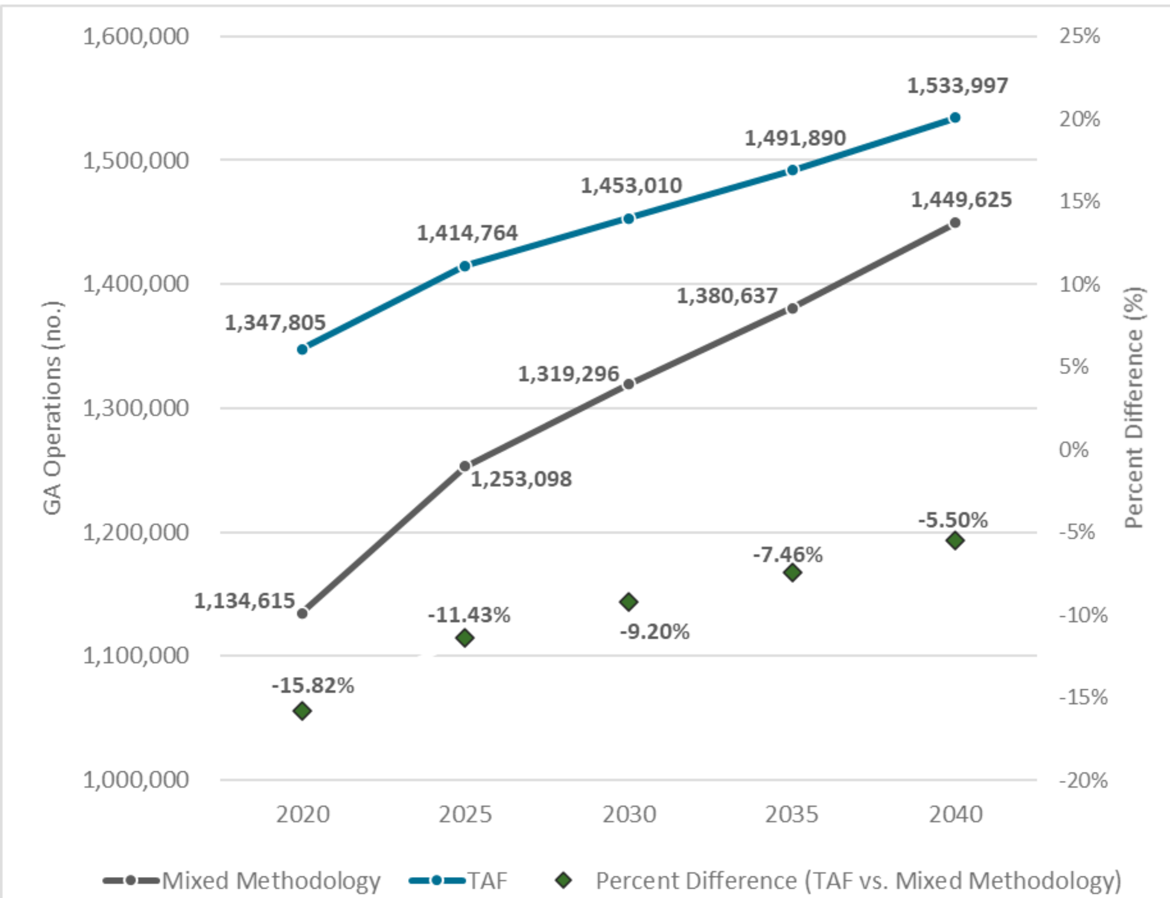
A comparison between the 2022 MnSASP forecast and TAF is depicted in Figure 3.15, with comparison by airport provided in Table A.7 in Appendix A.

Table 3.6. Preferred Mixed Methodology of the 2022 MnSASP versus TAF (Number and Percent Difference)

Forecast Timeframe	Year	Preferred Mixed Methodology	TAF	% Difference
Base Year	2020	1,134,615	1,347,805	-15.82%
Base Year + 5 Years	2025	1,253,098	1,414,764	-11.43%
Base Year + 10 Years	2030	1,319,296	1,453,010	-9.20%
Base Year + 15 Years	2035	1,380,637	1,491,890	-7.46%
Base Year + 20 Years	2040	1,449,625	1,533,997	-5.50%
	N/A	1.22%	0.65%	0.58%

Sources: W&P, 2021; FAA Aerospace Forecasts 2021 - 2041; Kimley-Horn, 2022; FAA TAF (accessed May 2021)

Figure 3.15. Preferred Mixed Methodology of the 2022 MnSASP versus TAF (Number and Percent Difference)



Sources: W&P, 2021; FAA Aerospace Forecasts 2021 - 2041; Kimley-Horn, 2022; FAA TAF (accessed May 2021)

3.4. Operational Threshold Analysis

Forecasting is one of the primary tools that airport planners use to identify future airport improvement needs. The results of such analyses can be used to evaluate the types of facilities and services may be required to support aircraft and the pilots, passengers, and cargo they serve, as well as the general timeframes in which those improvements are justified. The 2022 MnSASP established three operational thresholds for Minnesota's GA airports by state classification. These thresholds represent planning activity levels (PALs). Airports should be evaluated for additional development when annual operations achieve the established PALs. Operational thresholds established for each airport classification were reviewed and validated with the Operations and Forecasting Focus Area Working Group and developed in conjunction with MnDOT Aeronautics.

It is important to note that airport operations provide one perspective on airport facility needs. Critical aircraft, defined as the most demanding aircraft conducting at least 500 operations, are a key element in airfield planning and design. Planning decisions are driven not only by how many operations are occurring, but also the type of aircraft conducting those operations. Other indicators of aviation demand such as enplanements (as applicable), based aircraft, and air cargo activities must also be considered during airport planning processes. Identified facility needs defined in this section does not imply FAA funding eligibility or justification at NPIAS airports.

The recommended airport development needs applied in this analysis are based on the airport metrics established in Phase I of the MnSASP and validated during Phase II.[12] These airport metrics provide the recommended facilities, services, and administrative items that an airport should provide to optimally support the aviation activities typically occurring at airports within each state classification. Table 3.7 provides the operational thresholds (i.e., number of annual operations) established by classification. These numbers were calculated by applying the Jenks natural break algorithm to the total annual operations that occurred during the baseline year (2018 - 2020, see Section 3.2.2). Thresholds provide three PALs representing low, medium, and high numbers of annual operations.

Table 3.7. Operational Thresholds by State Classification (GA Only)

State Classification (GA Only)	No. of Annual Operations - PAL 1 (Low)	No. of Annual Operations - PAL 2 (Medium)	No. of Annual Operations - PAL 3 (High)
Key GA	6,417	21,275	80,602
Intermediate Large	1,576	9,733	29,974
Intermediate Small	454	7,125	23,010
Landing Strip Turf	200	1,213	5,029

Sources: 5010 Airport Master Record, Various Years; FAA TFMSC, 2018 - 2020 (accessed May 2021); Kimley-Horn, 2023

[12] *Airport metrics are discussed at length in **Chapter 2. Phase I Validation** of the 2022 MnSASP Technical Report.*

Table 3.8 provides recommended, required, and as-needed airport facilities, services, and administrative items by state classification (GA airports only) for each operational threshold (referred to as PALs). Table A.8 in Appendix A reports the forecast year in which each GA state system airport are anticipated to achieve each established PAL. It is important to reiterate that annual operations only provide one factor associated with airport development needs. These operational thresholds provide airport system planning-level guidance only and do not replace master planning activities. Airports are responsible for preparing airport-specific planning documents to monitor and justify development needs over time. It should be noted that Identified facility needs as prescribed by Table 3.8 do not imply FAA funding eligibility or justification at NPIAS airports.

ACRONYMS

The acronyms used in the table are defined as follows:

ALP	Airport Layout Plan
ASOS	Automated Surface Observation System
AWOS	Automated Weather Observation System
HIRLs	High Intensity Runway Lights
LIRLs	Low Intensity Runway Lights
LPV	Localizer Performance with Vertical Guidance
MIRLs	Medium Intensity Runway Lights
MP	Master Plan
NAVAIDs	Navigational Aids
REILs	Runway End Identifier Lights
RDC	Runway Design Code
TDG	Taxiway Design Group
VGSI	Visual Glideslope Indicator

Table 3.8. GA Operational Thresholds (PALs) by State Classification

Metric	Targets by State Classification - Key General Aviation	Targets by State Classification - Intermediate Large	Targets by State Classification - Intermediate Small	Targets by State Classification - Landing Strip Turf
FACILITY METRICS	KEY GENERAL AVIATION FACILITY TARGETS	INTERMEDIATE LARGE FACILITY TARGETS	INTERMEDIATE SMALL FACILITY TARGETS	LANDING STRIP TURF FACILITY TARGETS
Primary Runway Width	PAL 1	PAL 1	PAL 1	NA
	Required: At least 100 feet minimum, corresponding to FAA design standards for RDC C-II and B-II with visibility minimums < ¾ mile to accommodate instrument approaches < ½ mile visibility minimum	Required: At least 60 feet minimum, corresponding to the minimum width of a hard surface runway in Minnesota Administrative Rules Recommended: A width of 75 feet is recommended to align with RDC B-II runways with one-mile visibility minimums	Required: At least 75 feet minimum, corresponding to the minimum width of turf runway provided in Minnesota Administrative Rules	None
Runway Lighting	PAL 1 (REQUIRED) / PAL 2 (RECOMMENDED)	PAL 2	PAL 2	PAL 1
	Required: MIRLs Recommended: HIRLs	Required: MIRLs	Required: MIRLs	Required: Edge markers for turf runways without lighting Recommended: LIRLs
Primary Runway Approaches	PAL 1 (REQUIRED) / PAL 2 (RECOMMENDED)	PAL 2 (REQUIRED) / PAL 3 (RECOMMENDED)	PAL 2 (REQUIRED) / PAL 3 (RECOMMENDED)	PAL 1
	Required: Precision approach with minimums of ¾ mile to at least one primary runway end Recommended: Precision approach with minimums of ½ mile to at least one primary runway end	Required: Non-precision instrument approach with one-mile visibility or lower to at least one runway end Recommended: Approaches with vertical guidance (e.g., LPV)	Required: Non-precision instrument approach with one-mile visibility or lower to at least one runway end Recommended: Approaches with vertical guidance (e.g., LPV)	Required: Visual approaches
Parallel Taxiway	PAL 1	PAL 2	PAL 1 (REQUIRED) / PAL 3 (RECOMMENDED)	PAL 2 (REQUIRED) / PAL 3 (RECOMMENDED)
	Required: Full parallel taxiway to align with the requirement of a precision approach with less than one-mile visibility	Required: Full parallel taxiway if the airport has an approach minimum of less than one mile. A partial parallel taxiway is required if the visibility minimums are one mile or greater	Required: Partial parallel taxiway Recommended: Full parallel taxiway	Required: Taxiway connectors Recommended: Partial parallel taxiway
Taxiway Width	PAL 1	PAL 2 (REQUIRED) / PAL 3 (RECOMMENDED)	PAL 3	PAL 3
	Required: At least 35 feet corresponding to TDG 2	Required: At least 25 feet corresponding to TDG 1A and 1B aircraft Recommended: At least 35 feet for TDG 2	Required: At least 25 feet corresponding to TDG 1A and 1B aircraft	Required: At least 25 feet corresponding to TDG 1A and 1B aircraft
Navigation Systems	PAL 2	PAL 1	PAL 1	PAL 1
	Required: Approach lighting system, REILs, VGSI, beacon, wind cones	Required: VGSI, wind cone, rotating beacon	Required: Beacon, wind cone	Required: Wind cone
Weather Reporting	PAL 1	PAL 2	PAL 2	PAL 3
	Required: AWOS or ASOS	Recommended: AWOS	Recommended: AWOS	Recommended: AWOS as-needed

Metric	Targets by State Classification - Key General Aviation	Targets by State Classification - Intermediate Large	Targets by State Classification - Intermediate Small	Targets by State Classification - Landing Strip Turf
Aircraft Parking	PAL 2	PAL 3	PAL 3	PAL 3
	Required: Tiedowns for at least three more aircraft than are normally parked at the airport	Required: Tiedowns for at least three more aircraft than are normally parked at the airport	Required: Tiedowns for at least three more aircraft than are normally parked at the airport	Required: Tiedowns for at least three more aircraft than are normally parked at the airport
GA Terminal / Admin Bldg.	PAL 2	PAL 3	PAL 3	PAL 3 (REQUIRED AND RECOMMENDED)
	Required: GA terminal with a phone and restroom	Required: GA terminal with a phone and restroom	Required: GA terminal with a phone and restrooms	Required: Phone and restroom Recommended: GA terminal with a phone and restroom
Auto Parking	PAL 1	PAL 1	PAL 1	PAL 1
	Required: Adequate parking as determined at the local level	Required: Adequate parking as determined at the local level	Required: Adequate parking as determined at the local level	Required: Adequate parking as determined at the local level
Fencing	PAL 2 (REQUIRED AND AS-NEEDED)	PAL 3 (REQUIRED AND AS-NEEDED)	PAL 3	PAL 3
	Required: Controlled vehicle access As-needed: Full perimeter and wildlife fencing as determined at the local level	Required: Controlled vehicle access As-needed: Full perimeter and wildlife fencing as determined at the local level	As-needed: Controlled vehicle access and full perimeter and wildlife fencing as determined at the local level	As-needed: Controlled vehicle access and full perimeter and wildlife fencing as determined at the local level
Airport Surfaces	PAL 1	PAL 1	PAL 1	PAL 1
	Required: All airport surfaces must be clear of obstructions	Required: All airport surfaces must be clear of obstructions	Required: All airport surfaces must be clear of obstructions	Required: All airport surfaces must be clear of obstructions
Services Metrics	Key General Aviation Service Targets	Intermediate Large Service Targets	Intermediate Small Service Targets	Landing Strip Turf Service Targets
Fuel	PAL 2	PAL 3 (RECOMMENDED AND REQUIRED	PAL 3 (RECOMMENDED AND REQUIRED)	PAL 3 (AS-NEEDED)
	Recommended: 100LL and Jet A fuel	Recommended: 100LL As-Needed: Jet A	Recommended: 100LL As-Needed: Jet A	As-needed: 100LL
Courtesy / Rental Cars	PAL 2	PAL 3	PAL 3	PAL 3
	Recommended: Rental and courtesy cars	Recommended: Courtesy cars	Recommended: Courtesy cars	As-needed: Courtesy cars
Transient Aircraft Storage	PAL 2	PAL 3 (AS-NEEDED)	PAL 3 (AS-NEEDED)	PAL 3 (AS-NEEDED)
	Recommended: Heated transient storage	As-needed: Transient storage	As-needed: Transient storage	As-needed: Transient storage

Metric	Targets by State Classification - Key General Aviation	Targets by State Classification - Intermediate Large	Targets by State Classification - Intermediate Small	Targets by State Classification - Landing Strip Turf
Administrative Metrics	Key General Aviation Administrative Targets	Intermediate Large Administrative Targets	Intermediate Small Administrative Targets	Landing Strip Turf Administrative Targets
ALPs/ MP	PAL 1	PAL 1	PAL 1	PAL 2
	Required: ALP and MP updates at least every 10 years	Required: ALP and MP updates at least every 15 years	Required: ALP and MP updates at least every 15 years	Required: ALP updates as-needed
Airport Zoning	PAL 1	PAL 1	PAL 1	PAL 1
	Required: Adequate airport zoning (per state law)	Required: Adequate airport zoning (per state law)	Required: Adequate airport zoning (per state law)	Required: Adequate airport zoning (per state law)
Clear Zone Ownership	PAL 1	PAL 1	PAL 1	PAL 1
	Required: Clear zones controlled in fee title	Required: Clear zones controlled in fee title	Required: Clear zones controlled in fee title	Required: Clear zones controlled in fee title
Minimum Standards	PAL 1	PAL 1	PAL 1	PAL 1
	Recommended: Documented minimum standards	Recommended: Documented minimum standards	Recommended: Documented minimum standards	Recommended: Documented minimum standards

Sources: MnDOT Aeronautics, 2021; Kimley-Horn, 2022

3.5. Identification of Airports with Operations Exceeding ARC

The total number of operations occurring at an airport is one way to identify airports where capacity enhancements are recommended. An ARC analysis provides another means of assessing airports' abilities to optimally support the aviation activities occurring there by looking at the type of aircraft utilizing the airport (as opposed to the number as in the case of operations forecasts). An ARC analysis identifies airports where a significant portion of activity is conducted by aircraft larger than the airport is designed to support based on the design or critical aircraft.[13] Many facets of airport planning and design are driven by an airport's ARC. The ARC is comprised of two components:

- **Aircraft Approach Category (AAC):** Represented by a letter A through E, the ACC indicates the approach speed of an airport's design aircraft
- **Airplane Design Group (ADG):** Represented by a Roman numeral I through VI, the ADG indicates the wingspan and tail height of an airport's design aircraft

The combination of the AAC and ADG compose an airport's ARC. Classifications are summarized in **Table 3.9**. Airports, runways, and aircraft can be referred to by these characteristics.

Table 3.9. ARC Summary

AAC	Approach Speed	ADG	WINGSPAN (feet)	Tail Height (feet)
A	Less than 91	I	Less than 49	Less than 20
B	91 to 120	II	49 to 78	21 to 29
C	121 to 140	III	79 to 117	0 to 44
D	141 to 165	IV	118 to 170	45 to 59
E	166 or Greater	V	171 to 213	60 to 65
E	166 or Greater	VI	214 up to but less than 262	66 up to but less than 80

Source: FAA AC 150/5300-13A, Change 1, Airport Design, 2019

In general, smaller ARCs (A-I through B-I) represent small, single- and multi-piston aircraft. ARCs in the B-II to C-III categories represent turbo-prop and corporate aircraft. The largest categories (C-IV and up) generally represent by commercial airliners and heavy military aircraft. **Table 3.10** provides example aircraft in each ARC.

Table 3.10. Example Aircraft by ARC

ARC	Example Aircraft
A-I and B-I, including A-I and B-I small aircraft	Beech Bonanza, Cessna 172, Beech King Air 100, Cessna 421, Piper Cheyanne
A-II and B-II	DHC Twin Otter, Super King Air 200, Cessna Citation II
A-III, B-III C-I through C-III D-I through D-III	DHC Dash 8, Beech 400, Learjet 25, Embraer ERJ-170, Gulfstream 500, Bombardier Q-400

[13] A design or critical aircraft is defined as the most demanding aircraft conducting at least 500 operations at the airport.

ARC	Example Aircraft
A-IV and B-IV C-IV through C-VI D-IV through D-VI	Boeing 757, Boeing 767, Boeing 777, Lockheed C-130 Hercules
E-I through E-VI	Special military use only

Source: FAA AC 150/5300-13A (Consolidated Change 1), Airport Design (Table 3-1), 2019

The ARC analysis was conducted by comparing 2020 aircraft operations with the ARC designation of each airport. ARC designations were obtained from the latest MnDOT-approved ALPs collected during the MnSASP airport inventory. Operations data were collected from the FAA's TFMSC for calendar year 2020 for all Minnesota system airports. The TFMSC only collects data from filed flight plans and/or when flights are detected in the NAS. As such, most VFR and some non-en route IFR traffic is excluded. Because of this data limitation, 100 Minnesota system airports had adequate data for analysis. This ARC analysis methodology is intended to be replicable for MnDOT Aeronautics to apply in the future to inform future system planning.

As **Table 3.11** shows, five airports experience operations by aircraft more demanding than their existing ARC designations more than 10 percent of the time. Brooten Municipal Airport (6D1) hosts the highest percent of operations above its existing ARC designation at 33 percent. Brooten Municipal Airport should continue to monitor the type of operations it typically supports to ensure safety and operational efficiency. Facility improvements may be warranted at some point in the future to achieve B-II designation (indicated as Brooten Municipal Airport's ultimate runway build-out on its 2011 ALP).

Table 3.11. Airports with More than 10 Percent of Total Operations Exceeding Existing ARC

Associated City	Airport Name	FAA ID	Existing ARC	Ultimate ARC	ALP Approval Date	Total TFMSC Operations - 2020	Percent of Ops Greater than Existing ARC
Brooten	Brooten Municipal Airport	6D1	A-I	B-II	2011	3	33%
New Ulm	New Ulm Municipal Airport	ULM	B-II	B-II	2009	333	23%
Duluth	Duluth International Airport	DLH	C-III	D-V	2018	13,148	16%
Preston	Preston Fillmore County Airport	FKA	B-I	B-II Small	2020	65	14%
Long Prairie	Long Prairie Airport (Todd Field)	14Y	A-I	B-II	2006	23	13%

Sources: FAA AC 150/5300-13A (Consolidated Change 1), Airport Design (Table 3-1), 2019; TFMSC, 2020 (accessed May 2021)

3.6. Summary

Understanding the current and future activities occurring at airports is critical to assessing potential airport improvement needs and engaging in a proactive planning process. Future demands help guide planning-level decisions about airport development needs and estimate potential investment requirements in the long-term. Each of the components of the 2022 MnSASP forecasting effort, including estimates of baseline operations, forecasting operations, operational thresholds, and operations exceeding existing ARCs, provides a nuanced perspective on how demands may change over time. While airport-level planning is required to make specific funding allocation decisions, these interrelated analyses provide critical insight into Minnesota's aviation environmental in the years and decades to come.

As shown on the following pages, the GA operations forecasts developed during the 2022 MnSASP were approved by the FAA on February 7, 2023.

U.S. Department of Transportation
Federal Aviation Administration

Dakota-Minnesota Airports District Office
Bismarck Office
2301 University Drive, Building 23B
Bismarck, ND 58504

Dakota-Minnesota Airports District Office
Minneapolis Office
6020 28th Avenue South, Suite 102
Minneapolis, MN 55450

February 7, 2023

Mr. Rylan Juran, C.M.
Aviation Planning Director
Minnesota Department of Transportation
Office of Aeronautics
395 John Ireland Boulevard, Mail Stop 410
Saint Paul, MN 55155-1800

Minnesota State Aviation System Plan (Phase II) Forecast Approval
State of Minnesota (MNS)
AIP 3-27-0000-010-2020

Dear Mr. Juran:

The FAA approves the General Aviation (GA) Aircraft Operations Forecast as summarized in Table 3.6 of the draft Minnesota State Aviation System (MnSASP) Phase II report for use in the system planning study. This forecast approval is subject to the caveats identified below being inserted as a disclaimer at the beginning of the forecast document.

	Base Year (2020)	Forecast (2040)	Data Source
GA Aircraft Operations	1,134,615	1,449,625	Table 3.6
Source: Draft Minnesota State Aviation System Plan Phase II, Chapter 3, January 2023			

This forecast was prepared at the same time as the evolving impacts of the COVID-19 public health emergency. Forecast approval is based on the methodology, data, and conclusions at the time the document was prepared. However, consideration of the impacts of the COVID-19 public health emergency on aviation activity is warranted to acknowledge the reduced confidence in growth projections using currently-available data.

Accordingly, FAA approval of this forecast does not constitute justification for future projects. Justification for future projects will be made based on activity levels at the time the project is requested for development. Documentation of actual activity levels meeting planning activity levels will be necessary to justify Federal funding for eligible projects.

Please note that all GA airport operations estimates and forecasts presented in the MnSASP shall not be used for individual airport planning or funding decisions. Each airport is expected to prepare their own aviation activity forecast for FAA review and approval as a basis for justifying the planning and proposed development identified in the airport sponsor's Capital Improvement Plan (CIP).

If you have any questions or would like to discuss this information further, please feel welcome to contact me at (612) 253-4635 or marcus.s.watson@faa.gov.

Sincerely,

MARCUS SLOAN WATSON
Digitally signed by MARCUS SLOAN WATSON
Date: 2023.02.07 11:50:52 -06'00'

Marcus S. Watson, C.M.
Community Planner

cc: Zach DeVeau, Kimley-Horn (email)
Lindsay Butler, FAA (email)
Gina Mitchell, FAA (email)