F Las Vegas Metroplex Optimization of Airspace and Procedures Study Team Final Report

Federal Aviation Administration

Las Vegas Metroplex

Optimization of Airspace and Procedures

Study Team Final Report

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by

Las Vegas Metroplex Study Team

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1 Background

In September 2009, the Federal Aviation Administration (FAA) received the Radio Technical Commission for Aeronautics Task Force 5 (RTCA) Final Report on Mid-Term NextGen Implementation. The final report contained top priorities for the implementation of NextGen initiatives. These initiatives include the formation of teams leveraging FAA and industry Performance Based Navigation (PBN) expertise and experience to expedite implementation of optimized airspace and procedures.

Metroplex was developed in direct response to the recommendations from Task Force 5 to provide a systematic, integrated, and expedited approach to implementing PBN procedures and associated airspace changes. This process focuses on a geographic area, rather than a single airport and from planning to post-implementation, should have an expedited project schedule of approximately three years.

Metroplex projects are centered on two types of collaborative teams:

- Metroplex Study Teams (MSTs) provides a comprehensive, front-end strategic look at each major metroplex
  - MSTs are comprised of Subject Matter Experts (SMEs)
  - SMEs are selected from geographic areas outside of the metroplex site
- Based on the recommendations of the MST, the Design and Implementation (D&I) Team provides a systematic, effective approach to the design, evaluation, and implementation of PBN-optimized procedures and associated airspace

2 Purpose of the Metroplex Study Team

The objective of the MST is to identify operational issues and propose PBN procedures and/or airspace modifications ultimately optimizing the operations within the study area. The MST utilizes existing aircraft equipage data, Area Navigation (RNAV) procedures, optimized descent and climb profiles to eliminate or reduce level segments, and adding direct RNAV routings in both the en route and terminal environments. The products of the MST will be used to scope future detailed design efforts.

3 Las Vegas Metroplex Study Team Analysis Process

3.1 Five Step Process

The Las Vegas MST followed a five step analysis process:

1. Collaboratively identify and characterize existing issues:
   a. Review current operations
   b. Solicit input to obtain an understanding of the broad view of operational challenges in the metroplex
   c. Solicit input to obtain pertinent environmental concerns
2. Propose conceptual procedure designs that will address the issues and optimize the operation:
   a. Obtain technical input from operational stakeholders

   b. Explore potential solutions to the identified issues
   c. Use an integrated airspace and PBN "toolbox" (Appendix A)
3. Quantitatively and qualitatively identify the expected benefits of the conceptual designs:
   a. Assess the impacts of conceptual designs
   b. Use objective and quantitative assessments, as required
4. Identify considerations and risks associated with the proposed changes:
   a. Describe high-level considerations (e.g., Spectrum Analysis)
   b. Risks (e.g., Safety Risk Management [SRM])
5. Document results

Steps 1 and 2 are worked collaboratively with local facilities operators, airport authorities, and Airport District Offices through a series of outreach meetings. Step 3 is supported by the Metroplex National Analysis Team (NAT). The methodology used for the quantitative analysis is described in Section 3.5. The NAT is a centralized analysis and modeling resource that is responsible for data collection, visualization, analysis, simulation, and modeling. Qualitative benefits are derived from expected results of optimization and input from local facilities and operators. Step 4 is conducted with the support of metroplex specialized experts. The specialized experts provide "on-call" expertise from multiple FAA lines of business, including environmental, safety, airports, and specific programs like Time Based Flow Management (TBFM). Step 5 is completion and documentation of all Study Team deliverables.

3.2 The Las Vegas MST Process and Schedule

- Administrative week, July 27, 2015 – July 31, 2015
- Kickoff meeting: August 4, 2015 at McCarran International Airport, Las Vegas, Nevada
  - Discuss concepts and proposed schedules
  - Establish facility Points of Contact (POC)
  - Make data requests
- First Outreach: Existing Operations and Planning
  - FAA Facilities:
    - Los Angeles Air Route Traffic Control Center (ZLA) August 11, 2015 at ZLA, Las Vegas Conference Room, Palmdale, California
    - Las Vegas and Adjacent Facilities August 12, 2015 at McCarran Annex, Conference Room 1A, Las Vegas, Nevada
  - Industry Stakeholders: August 13 at McCarran International Airport, Terminal 1 Commissioner's Room, Las Vegas, Nevada
- Las Vegas MST work (Issue Matrix and Notional Design Development): August 17, 2015 – September 18, 2015
- Second Outreach: Enhancement Opportunities

    - FAA Facilities: September 22, 2015 and September 23, 2015 at McCarran Annex, Conference Room 1A, Las Vegas, Nevada
    - Industry Stakeholders: September 24, 2015 at McCarran International Airport, Terminal 1 Commissioner's Room, Las Vegas, Nevada
- Las Vegas MST work (focus on solutions, costs, and benefits): September 28, 2015 – October 23, 2015
- Final Outreach: Summary of Recommendations
    - FAA Facilities: October 29, 2015 at McCarran Annex, Conference Room 1A, Las Vegas, Nevada
    - Industry Stakeholders: November 5, 2015 at McCarran Annex, Conference Room 1A, Las Vegas, Nevada
- Documentation: Final report, final briefing, and Study Team package
    - Las Vegas MST work (complete all documentation): November 6, 2015 - November 19, 2015
    - Final report: November 20, 2015

There were three rounds of outreach meetings with local facilities, industry, and other stakeholders including: Department of Defense (DOD), business and general aviation, Clark County Department of Aviation (CCDOA), Phoenix Airport District Office (ADO), and others. The First Outreach focused on issue identification, the Second Outreach focused on enhancement opportunities, and the Final Outreach presented final recommendations and summarized the analyses of benefits, impacts, and risks. Assessments at this stage in the Metroplex process are expected to be high-level. The Las Vegas MST designed detailed procedures in an effort to provide a more defined road map for a D&I. Detailed analyses of benefits, impacts, and costs are expected after the D&I phase has been completed.

3.3 Las Vegas Study Area Scope

The Las Vegas Metroplex consists of airspace delegated to ZLA, Las Vegas Terminal Radar Approach Control (L30), and Nellis Air Traffic Control Facility (NATCF). The following airports were included in the Study Team Area Scope:

- McCarran International Airport (LAS)
- Henderson Executive Airport (HND)
- North Las Vegas Airport (VGT)
- Nellis Air Force Base (LSV)

3.4 Assumptions and Constraints

Metroplex is a focused approach to integrated airspace and procedures projects; thus, the proposed solutions center on PBN procedures and associated airspace redesign. The MST is expected to document the issues that are outside of the metroplex process and are described in Section 4.7 of this report.

The Metroplex expedited timeline and focused scope limit airspace and procedures solutions to those that can be achieved without requiring an Environmental Impact Statement (EIS) (e.g.,

only requiring an Environmental Assessment [EA] or qualifying for a Categorical Exclusion [CATEX]) and are within current infrastructure and operating criteria.

The MST may also identify airspace and procedures solutions that do not fit within the environmental and criteria boundaries of a Metroplex Project. These recommendations then become candidates for other integrated airspace and procedures efforts.

3.5 Assessment Methodology

Both qualitative and quantitative assessments are made to gauge the potential benefits of proposed solutions.

The qualitative assessments are those that the Las Vegas MST cannot measure but are expected to result from the implementation of the proposed solutions. These assessments include:

- Ability to enhance safety
- Impact on air traffic control (ATC) task complexity
- Reduction in communications (pilot and controller)
- Ability to laterally and/or vertically deconflict procedures
- Improved connectivity to en route structure
- Improved track predictability and repeatability
- Improved flight planning
- Modernization of the National Airspace System (NAS)
- Improved community awareness and perspective on procedure design

An example of qualitative assessment is ATC task complexity. ATC task complexity can be lessened through the application of structured PBN procedures versus the use of radar vectors, but quantifying that impact is difficult. Reduced communications between pilot and controller, as well as reduced potential for operational errors, are examples of metrics associated with controller task complexity that were not quantified.

For the quantitative assessments, the Las Vegas MST identified changes in track miles, level segments, fuel burn, and carbon emissions. Potential benefits were measured by comparing current flights to the Las Vegas MST proposed procedures using a Markov Chain Monte Carlo method[1] to approximate aircraft behavior based on distributions from historic radar tracks. Fuel burn for these aircraft was calculated using The MITRE Corporation's (MITRE) validated implementation of the European Organization for the Safety of Air Navigation (EUROCONTROL) Base of Aircraft Data 3.9 and Total Energy Model (BADA+TEM). The quantitative analyses compared the use of current procedures and shortcuts under baseline conditions with regular use of the procedures proposed by the Las Vegas MST.

3.5.1 Analysis and Design Tools

The following tools were employed by the MST and the NAT in the process of collecting and analyzing flight track data for designing conceptual procedures within the Las Vegas Metroplex:

[1] Markov Chain Monte Carlo methods are a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results.

- Performance Data Analysis and Reporting System (PDARS)
  - Historical traffic flow analysis using merged datasets to analyze multi-facility operations
  - Customized reports to measure performance and air traffic operations (i.e., fix loading, hourly breakdowns, origin-destination counts, etc.)
  - Identification and analysis of level flight segments
  - Graphical replays to understand and visualize air traffic operations
- Terminal Area Route Generation Evaluation and Traffic Simulation (TARGETS)
  - Comparison of actual flown routes to proposed routes when developing cost/benefit estimates
  - Conceptual airspace and procedure designs
  - Procedure flyability and criteria compliance
- Air Traffic Airspace Lab (ATALAB) National Offload Program (NOP) data queries provides quantification of traffic demand over time for specific segments of airspace
- Aviation System Performance Metrics (ASPM) provides identification of runway usage
- Traffic Flow Management System (TFMS)[2]
  - Traffic counts by aircraft group categories for annualizing benefits
  - Examination of filed flight plans to determine impact of significant re-routes
  - Operations Network (OPSNET) provides annual traffic counts
- Threaded Track (TT)
  - Flight trajectory data to examine existing traffic flows
  - Compiled from TFMS, ASDE-X (Airport Surface Detection Equipment), and NOP radar data
- Flight Pattern Distribution Generator (FPDG) provides arrival and departure distributions to predict fuel burn

3.5.2 Track Data Selected for Analyses

During the study process, a representative set of radar traffic data was utilized in order to maintain a standardized operational reference point. Radar track data for LAS from select days in 2014 and 2015 were used for:

- Visualizing the current flows and identifying where shortcuts were routinely applied, as well as where published procedures were more rigorously followed to develop baseline routes
- Determining the number, length, and location of level segments for the baseline of operational traffic

[2] TFMS was previously known as Enhanced Traffic Management System (ETMS).

- Developing conceptual solutions, including PBN routes and procedures which overlaid historical radar tracks, where appropriate
- Modeling of benefits from conceptual procedures
- The most frequently occurring runway use configurations, Configurations 1 and 3, were used in the analysis. Operational counts and weather data from ASPM were used to select seven days of track data for each configuration. Only days with good weather[3] were selected, and the days were selected across several months of the year to account for seasonal variations. Table 1 depicts the analysis days utilized by the Las Vegas MST.

Table 1. Observed Traffic Days

Configuration 1	Configuration 3
9/12/14	10/30/14
10/6/14	11/3/14
10/21/14	11/19/14
4/25/15	12/6/14
4/29/15	1/23/15
5/16/15	2/26/15
6/4/15	4/10/15

3.5.3 Annualization of Operations

The operations counts on each identified baseline route from the seven days of traffic data per configuration, as seen in Table 1, were adjusted up to an annual number based on a total operations count. For annualization purposes, a total of 522,067 aircraft operations[4] at LAS was used in the analysis.

The annual total of aircraft operations was adjusted to reflect that not all flights are expected to use the Las Vegas MST procedures. For example, outlier flights, and local flights, which account for approximately 4% of the total annual operations at LAS, were filtered from the flight track data because they are not expected to use the Las Vegas MST procedures. Additionally, operations which occurred under poor weather,[5] approximately 6% of the year, were excluded from the analysis. During poor weather it is assumed that flights would be continued to be re-routed, vectored, or held. The percentage of time in each runway configuration for LAS was determined by analyzing a year of historical data, and is shown in Figure 1.

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[3] ASPM weather impact level of "none" or "minor"

[4] OPSNET for calendar year 2014

[5] ASPM weather impact category of "moderate" or "severe"

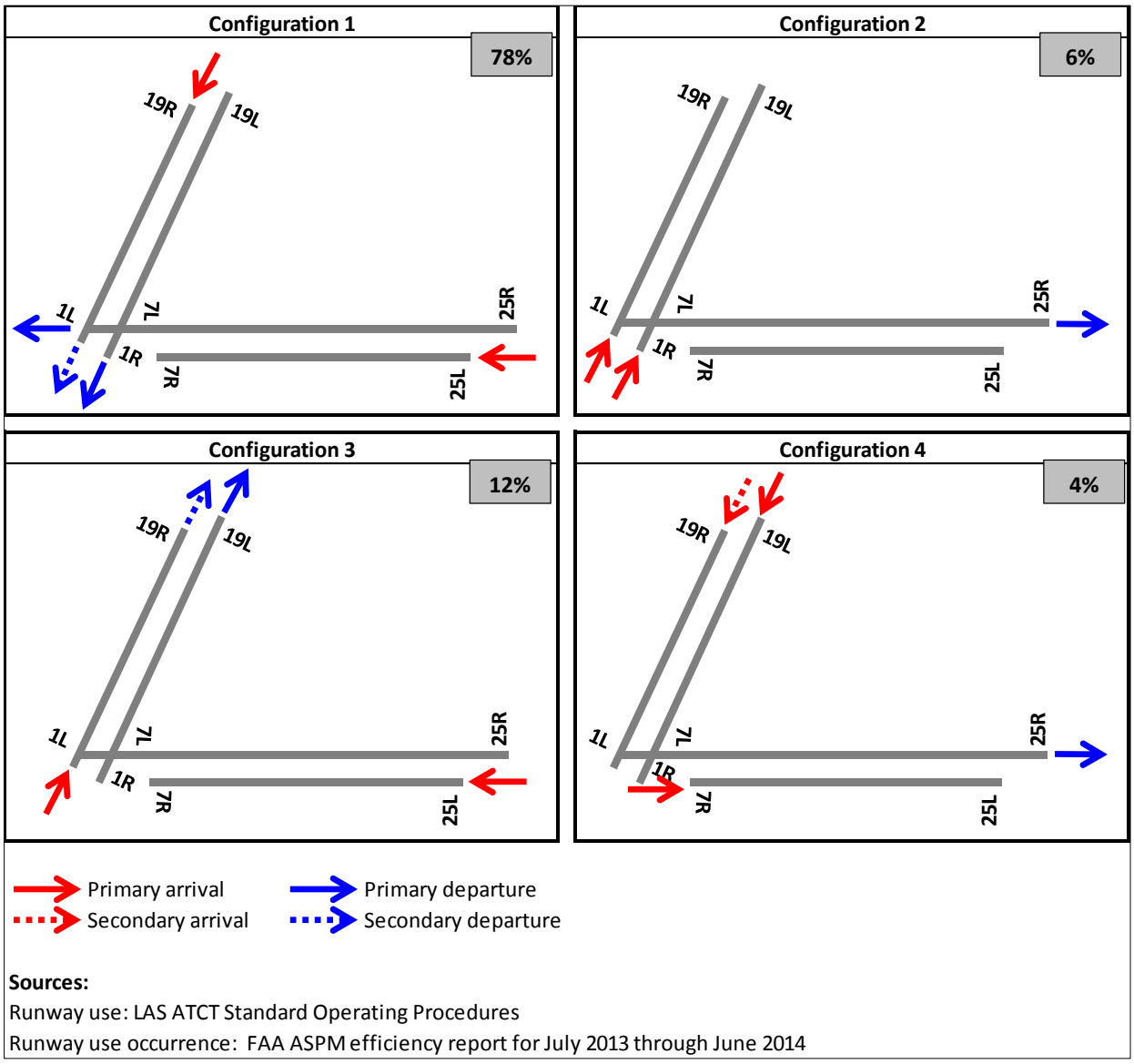

Figure 1. LAS Primary Runway Configuration

Although the Las Vegas MST created procedures and runway transitions for Configurations 2 and 4, these configurations were not included in the analysis, and it is assumed that no benefit will be realized during the estimated 10% of the time they occur.

3.5.4 Modeled Fleet Mix

Each baseline route identified at LAS had a corresponding fleet mix associated with the traffic flying that route. Aircraft types which made up 2% or less of the total traffic on a flow were excluded. A representative airport-wide fleet mix is shown in Table 2.

Table 2. LAS Fleet Mix[6]

Aircraft Type	Weighted Distribution
Boeing 737-700	33.8%
Boeing 737-800	19.5 %
Airbus A320	12.5 %
Boeing 737-300	7.8 %
Airbus A319	7.1 %
Boeing 737-900	4.3 %
MD-80	4.2 %
Airbus A321	3.8 %
Boeing 757-200	3.7%
Boeing 737-600	3.3%

3.5.5 Determining Percent of RNAV Capable Operations by Airport

The PBN Dashboard was used to determine the percent of operations at each airport that would benefit from the conceptual procedures.

Table 3 lists the RNAV equipage percentages assumed for the modeled Las Vegas airports.

Table 3. RNAV Equipage by Airport

Airport	% of RNAV-equipped IFR Operations
LAS	98%
HND	60 %
VGT	54 %
LSV	8 %

[6] Derived from TFMS for August 2014 through July 2015. Aircraft types accounting for 2% or less of the total IFR operations at LAS are not included.

3.5.6 Benefits Metrics

The benefits metrics were generated using the following process:

1. The radar track data from the days mentioned in Section 3.5.2 were parsed by flows into and out of LAS. These flows were then analyzed to determine geographic location, altitude, and length of level segments in the airspace. The average overall track flow length was also estimated.
2. Baseline routes were developed that mimic the average vertical and lateral path of the tracks in the flows.
3. Conceptual routes designed by the Las Vegas MST.
4. The impacts of the conceptual routes were estimated and compared to the baseline routes. FPDG was used to predict differences in flight trajectory and the resulting differences in fuel burn.

Figure 2 shows published, baseline, and proposed routes for an example flow with the comparisons for lateral savings highlighted and a sample vertical profile.

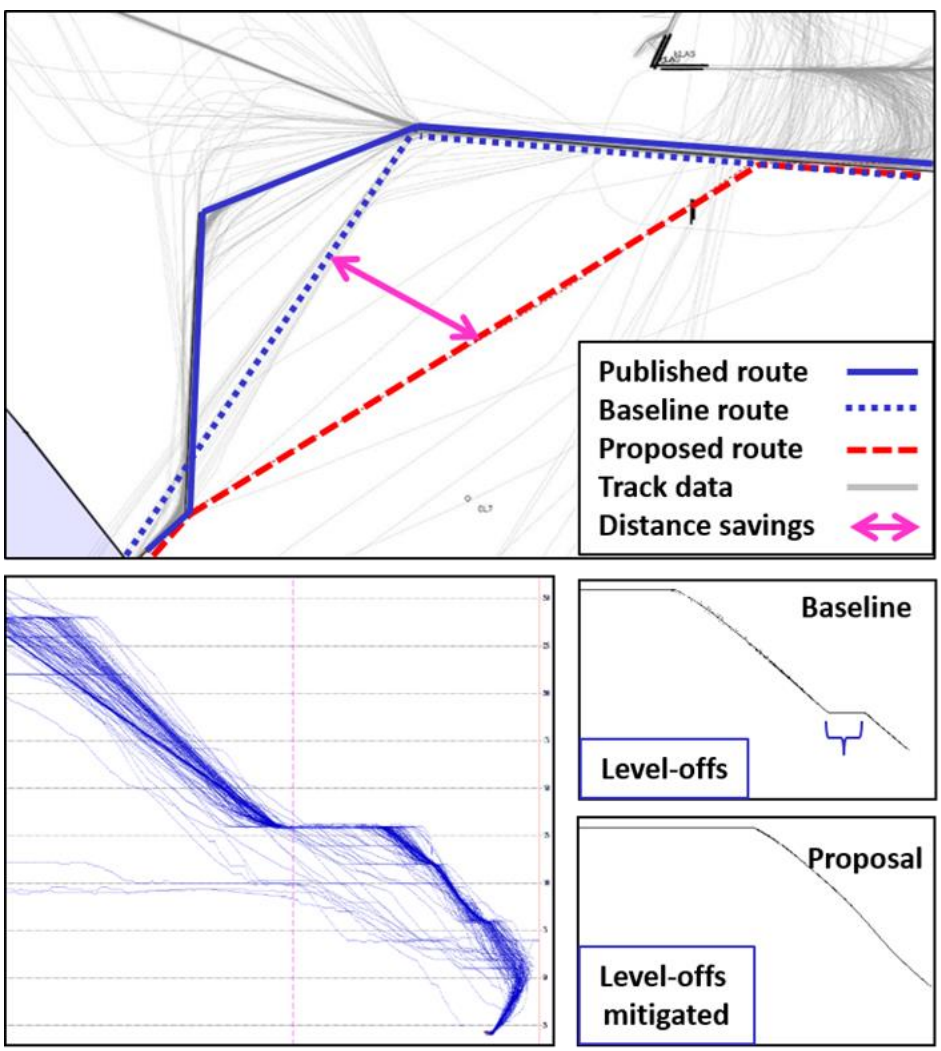

Figure 2. Sample Analysis: Lateral and Vertical Baselines

3.5.7 Fuel Savings Analysis

As discussed in Section 3.5.6, benefits were measured by comparing baseline routes developed from historical flight track data with the Las Vegas MST conceptual procedures. FPDG was used to approximate aircraft behavior and estimate fuel burn. The fuel savings were then annualized, assuming a fuel price per gallon of $2.85 based on fuel costs for 2014 from Research and Innovative Technology Administration (RITA) Bureau of Transportation Statistics.

Analysis results are in Section 4.

3.6 Key Considerations for Evaluation of Impacts and Risks

In addition to the quantitative and qualitative benefits assessments described in Section 3.5, the Las Vegas MST was tasked with identifying the impacts and risks from an operational and safety perspective. For each individual issue and proposed solution throughout Section 4 of this report, specific impacts and risks are identified. However, there are a number of impacts and risks that generally apply to many proposed solutions, as described below:

- Controller and pilot training: With the increased focus on PBN and the proposed changes in airspace and procedures, controller and pilot training will be a key consideration for nearly all proposals
- "Descend/climb via" procedure issues: The proposed use of "descend/climb via" clearances will similarly require controller and pilot training, and agreement must be reached during D&I on exactly how procedures will be requested, assigned, and utilized from both the FAA and user perspectives
- Aircraft equipage: There are challenges with working in a mixed equipage environment, and these risks must be considered during D&I. Procedures have been designed to take advantage of PBN efficiencies. In some cases conventional procedures may need to be addressed
- Safety Risk Management (SRM): Safety is always the primary concern and all of the proposed solutions will require following the SRM process
- Environmental issues: All proposed solutions are subject to environmental review, and the Metroplex schedule limits that review to a CATEX or EA rather than an EIS. The MST worked with environmental specialists to determine whether any of the proposed solutions has the potential for significant environmental impacts, and developed mitigation alternatives if necessary
- Community concerns: Engaging with airport authorities and Airport District Office to act as liaisons for the FAA to identify concerns that potentially would require amending procedures with less optimization in favor of mitigating impact to communities

4 Identified Issues and Proposed Solutions

This section presents the findings and results of the Las Vegas MST analysis. It reviews identified issues, proposed solutions, benefits, impacts, risks, and analysis results.

Originally, 145 issues were submitted to the Las Vegas MST (see Table 4). Similar issues raised by all involved parties were consolidated and categorized by the Las Vegas MST to determine potential solutions. Issues that required additional coordination and input or could not be

addressed within the limited time constraint of the Las Vegas MST were deferred to D&I. The Las Vegas MST identified issues that were deemed out of metroplex scope.

Table 4. Issues Disposition Summary

ATC Facility	Submitted Issues	Out of Scope	Deferred to D&I	Issues Worked
LAS ATCT	16	2	5	9
L30 TRACON	25	2	4	19
Satellite Airports	21	6	0	15
ZLA	65	12	14	39
Industry	18	3	0	15

4.1 Design Concepts

Currently, controllers rely on an assortment of conventional and RNAV procedures. The goal of the Metroplex is to use RNAV everywhere and RNP where beneficial. The use of PBN procedures will allow efficiency gains through optimized profile climbs/descents and enhanced lateral paths not reliant on ground based navigation. These efficiencies allow more repeatable, predictable flight tracks while reducing ATC task complexity and frequency congestion. To reduce chart clutter and enhance flight planning, the Las Vegas MST removed unused transitions. Runway transitions were designed where practical.

4.1.1 STAR Design Concepts

In general, the issues associated with the current arrival procedures to LAS are related to inefficient lateral and vertical paths, high terrain, conflicts with departure traffic, Q-Route connectivity, underutilized en route transitions, and insufficient surveillance coverage.

When feasible, vertical profiles and lateral paths were optimized, routes were deconflicted, and unused en route transitions were removed. The D&I Team may need to refine the location of waypoints to optimize en route transitions and add additional en route transitions to the Standard Terminal Arrival Routes (STARs). These conceptual STARs are procedurally deconflicted from Standard Instrument Departures (SIDs) and other STARs, where possible.

The Las Vegas MST proposed that L30's current airspace be expanded laterally to allow for runway transitions, space for sequencing, and the ability to issue landing runway assignments in a timely manner (see Figure 5). Airspace modifications that enable procedural efficiencies will be considered during D&I. Conventional (non-RNAV) STARs will need modification during D&I. Holding patterns were not designed and will be addressed in D&I. The Las Vegas MST recommended that all holding patterns be designed above or outside the lateral boundary of terminal airspace.

With respect to the conceptual arrival proposals, Figure 3, depicts benefits, impacts, and risks for the FAA and airspace users, as well as environmental considerations.

FAA Operational/Safety	
Benefits	**Impacts/Risks**
• Reduced communications • Multiple runway transitions • Reduced vectoring • Increased procedure conformance	• Runway transitions • LOA/SOP revisions • Training • Sectorization • Frequency Licensing

Airspace User	
Benefits	**Impacts/Risks**
• Reduced track miles • Reduced level segments • Reduced cost to carry • Reduced fuel burn and carbon emissions	• Preferred runway assignment • Training

Environmental Considerations
• Noise screening/analysis • Emissions analysis

Figure 3. Benefits, Impacts, and Risks of the Arrival Proposals

4.1.2 SID Design Concepts

The conceptual departure procedures should maintain unrestricted climbs while providing procedural segregation from other SIDs and STARs. It is expected that ATC will continue to tactically enable shorter routings and remove climb restrictions. Airspace modifications that enable procedural efficiencies will be considered during D&I.

RNAV SIDs with configuration dependent transitions were designed for repeatable, predictable flight paths. The Las Vegas MST recognizes that RNAV off-the-ground procedures may create a disbenefit in track miles flown in certain circumstances. The D&I Team may elect to further evaluate the combination of radar vectors and RNAV off-the-ground SIDs to determine the most beneficial method of departing from LAS.

With respect to the conceptual departure proposals, Figure 4 depicts benefits, impacts, and risks for the FAA and airspace users, as well as environmental considerations.

FAA Operational/Safety	
Benefits	**Impacts/Risks**
• Reduced communications • Multiple runway transitions • Reduced vectoring • Ability to procedurally segregate from STARs • Increased procedure conformance	• Runway transitions • LOA/SOP revisions • Training • Sectorization • Frequency Licensing
Airspace User	
Benefits	**Impacts/Risks**
• Reduced track miles • Reduced level segments • Reduced cost to carry • Reduced fuel burn and carbon emissions	• Runway assignment • Training
Environmental Considerations	
• Noise screening/analysis • Emissions analysis	

Figure 4. Benefits, Impacts, and Risks of the Departure Proposals

4.2 L30 Airspace Expansion

Issues

L30's current lateral airspace boundary is insufficient to accommodate runway transitions for LAS arrivals for all configurations. During periods of moderate and heavy traffic, sequencing to Runways 25L/R localizers extends back to ZLA airspace. Arrivals from the southwest, landing Runway 01L/R have difficulty meeting speed and altitude assignments. The current ZLA/L30 Transfer of Control Points (TCP) do not allow for the timely issuance of runway assignments.

The HND NOOTN STAR entry point into L30's airspace requires excessive coordination between ZLA Sectors 7 and 8.

Solutions

Expanding L30's current lateral boundary allowed the Las Vegas MST to develop Optimized Profile Descent (OPD) STARs with runway transitions for all configurations. The Las Vegas MST recommended airspace expansion would allow sequencing to Runways 25L/R to be contained within L30 airspace. Optimized procedures facilitate compliance with speed and altitude assignments thereby reducing transmissions and pilot/controller task complexity. The Las Vegas MST recommends ZLA issues the LAS landing direction[7] (one option per configuration per gate) and L30 issues the runway transition.

[7] See 20150922 Meeting Summary Notes- 2nd Facility Outreach, Item 1 in Decisions section

The proposed airspace modification reduces coordination and complexity, allows for timely runway assignments, and provides additional airspace for sequencing. The Las Vegas MST considered surveillance coverage when designing L30 airspace expansion. D&I should further analyze the airspace expansion to ensure adequate surveillance coverage. Figure 5 depicts the Las Vegas MST conceptual L30 airspace expansion.

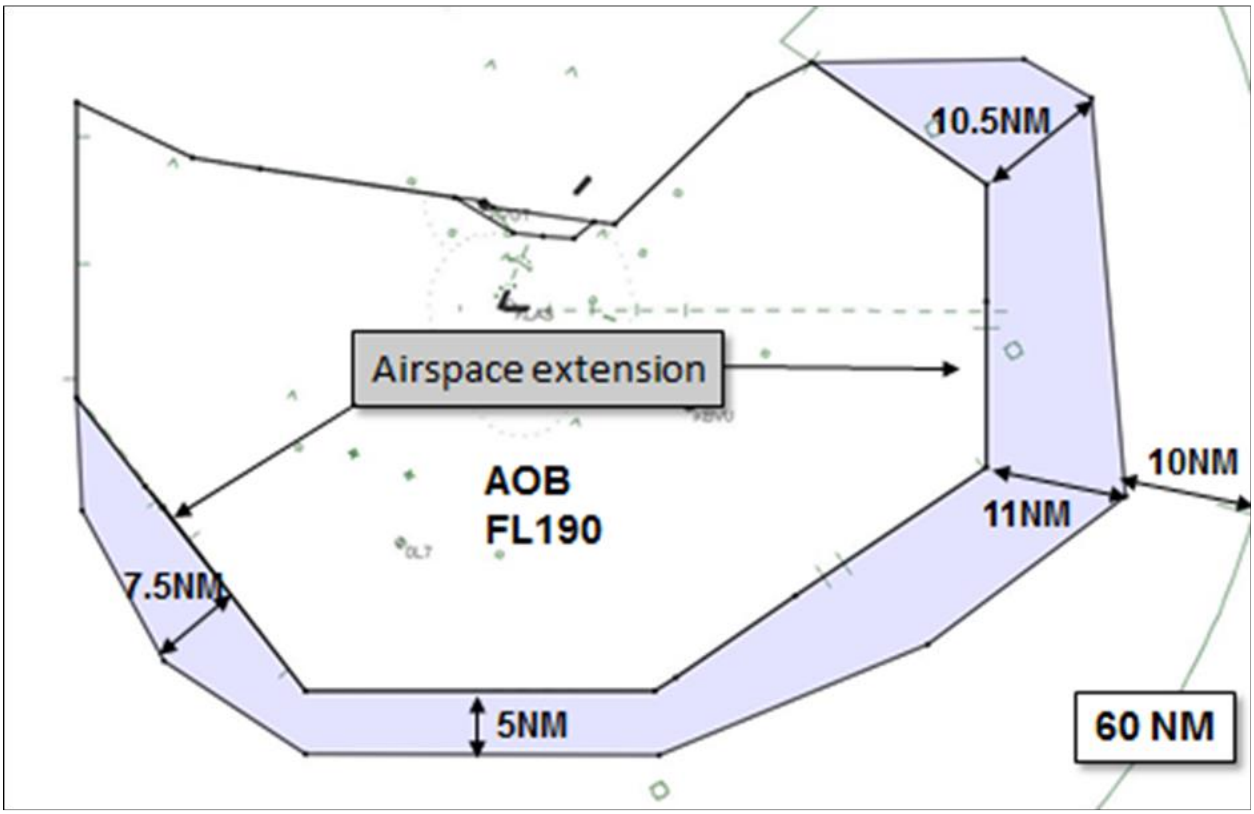

Figure 5. L30 Conceptual Airspace Expansion

4.3 LAS Conceptual Designs

The Las Vegas MST developed five conceptual OPD STARs and six conceptual RNAV SIDs for LAS. These procedures address stakeholder issues and concerns, and provide efficiencies through the use of PBN designs. Historical track data was used as a foundation for procedure and approach design and to capture "shortcuts." All procedures were designed with safety as the primary consideration.

4.3.1 LAS Arrivals

This section describes the operational issues, solutions, and expected benefits the Las Vegas MST has identified for arrivals to LAS. All procedures were designed with safety as the primary consideration.

4.3.1.1 LAS NE STAR

Issues

Stakeholders agree that the GRNPA STAR has numerous inefficiencies in its design. GRNPA arrivals incur an approximate ten nautical mile (NM) level-off at 12,000 feet and an approximate 10 to 20 NM level off at 8,000 feet to comply with inefficient procedures. The GRNPA STAR does not provide repeatable and predictable course guidance to runways other than Runways 19L/R. The lack of runway transitions requires controllers to vector aircraft to other runways increasing pilot/controller task complexity.

The sharp left turn at LUXOR creates excessive compression at the L30/ZLA boundary. L30 controllers vector arrivals off the procedure to maintain in trail spacing. Sequencing three flows at KSINO by multiple ZLA sectors is complex and inefficient.

Solutions

The Las Vegas MST created an RNAV OPD STAR (NE STAR) usable for all configurations which reduces flight track miles and level segments and connects to current and proposed Standard Instrument Approach Procedures (SIAP). The LAS NE STAR incorporates altitude windows and speed constraints to reduce pilot/controller task complexity.

During the Second Outreach ZLA provided input as to the location of the en route transitions sequencing point. This new location is east of the current KSINO merge point.

Route Description

During procedure design the Las Vegas MST looked at multiple options to replace the current GRNPA STAR. These options included the addition of altitude window constraints, realignment of current and additional runway and en route transitions. During the Second Outreach, L30 requested that the Runways 07L/R transitions be eliminated.

The LAS NE STAR was designed with three en route transitions which are not reliant upon ground based navigation. The northern transition does not have a top of descent (TOD) restriction since it is lightly used, the other two transitions were located to capture current traffic shortcuts and have a TOD constraint of at or above Flight Level (FL) 290 and 280 knots. The three en route transitions merge at ST150. The location of ST150 was determined by ZLA to accommodate sequencing prior to the L30 conceptual boundary. The restrictions and fixes are depicted in Figure 6.

As depicted in Figure 7, waypoint ST151 was placed at the L30 conceptual boundary to facilitate timely issuance of a runway transition. Runway transitions begin at ST152 and altitude windows were established at specific waypoints to optimize and deconflict the procedure for all configurations. All runway transitions were merged with current and proposed SIAPs. In the final design, the Runways 07L/R transitions were removed.

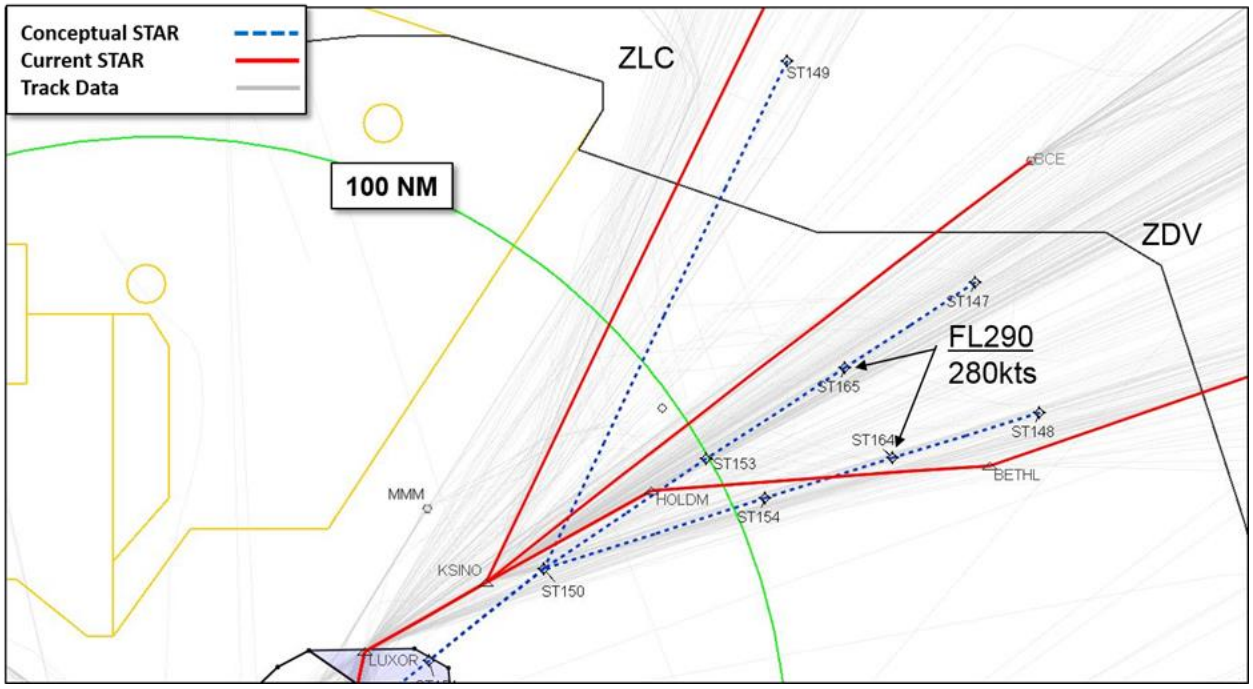

Figure 6. GRNPA STAR and Proposed LAS NE STAR En Route View

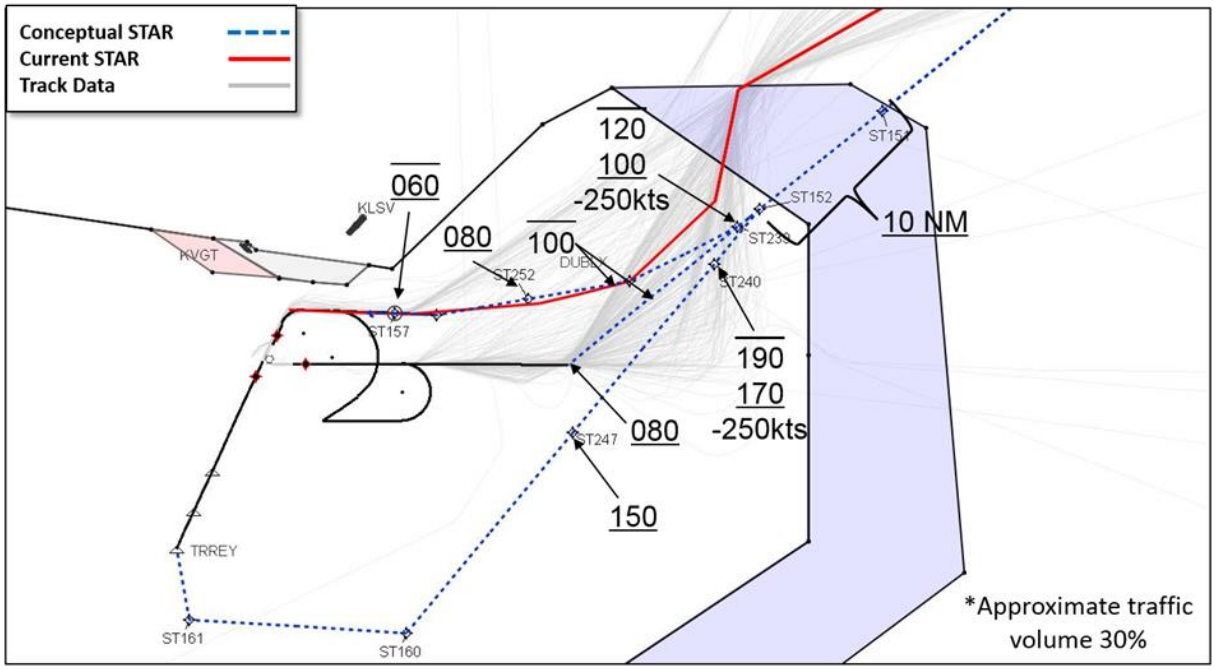

Figure 7. GRNPA STAR and LAS NE STAR Terminal View

Qualitative Benefits

The LAS NE STAR was designed for repeatable, predictable course guidance for all configurations with connectivity to proposed and current SIAPs. By optimizing the procedure, there should be an overall reduction in phraseology and the number of pilot/controller transmissions which will reduce task complexity and readback/hearback errors.

The LAS NE STAR route was designed to minimize interaction in the en route environment between arrival and departure flows. In the terminal environment, this STAR is procedurally deconflicted from all conceptual SIDs.

Quantitative Benefits

The Las Vegas MST reduced lateral track miles by reviewing historical flight track data and designing more direct routes. Optimizing the vertical profile after the TOD, the LAS NE STAR reduces time and distance in level flight. These benefits result in a reduction in fuel burn and carbon emissions. Projected annual savings for the conceptual LAS NE STAR are shown in Table 5.

Table 5. Estimated Annual Savings for LAS NE STAR

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS NE STAR	**794,000**	**$2,263,000**	**7,500**
* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred			

4.3.1.2 LAS SE1 STAR

Issues

Stakeholders agree that the TYSSN STAR has numerous inefficiencies in its design. TYSSN arrivals incur approximately 15 to 20 NM level-offs at 12,000 feet and at 8,000 feet to comply with inefficient procedures. TYSSN STAR does not provide repeatable and predictable course guidance to runways other than Runways 25L/R. The lack of runway transitions requires controllers to vector aircraft to other runways increasing pilot/controller task complexity.

A sharp right turn at KADDY creates overtake situations at the L30/ZLA boundary. Currently, L30 controller's vector arrivals off the procedure to maintain in trail spacing. Two arrival transitions and the PRFUM SID all fly over KADDY requiring ZLA sectors to descend arrivals early to maintain vertical separation. The TYSSN STAR does not align with the proposed Phoenix Metroplex procedures.

Solutions

The Las Vegas MST created two RNAV OPD STARs (LAS SE1 STAR, LAS SE2 STAR) usable for all configurations which reduce overall flight track miles, minimize level segments and connect to current and proposed SIAPs. The dual STARs in the southeast quadrant may require the use of TBFM and an update to the TBFM adaptation. The LAS SE1 STAR

incorporates altitude windows and speed constraints to reduce pilot/controller task complexity and readback/hearback errors.

Route Description

The Las Vegas MST looked at multiple options to replace the TYSSN STAR. These options included the addition of altitude window constraints, realignment of current and additional runway and en route transitions.

During the second outreach, ZLA and L30 expressed concerns about the use and management of dual arrivals. Las Vegas MST developed ATC assigned cross over transitions that will allow for a single arrival flow when warranted (i.e., weather impacts or reduced arrival rates). L30 requested the Runway 19 transition be moved further east of PRINO to allow for sequencing with the LAS NE STAR.

The LAS SE1 STAR was designed with two en route transitions which are not reliant on ground based navigational aids. The two transitions are located to capture current traffic shortcuts and have a TOD constraint of at or above FL290 and 280 knots. The two en route transitions merge at ST166. Las Vegas MST developed an ATC assigned cross over transition from the LAS SE2 STAR that will allow for a single arrival flow when warranted (i.e., weather impacts or reduced arrival rates). This route joins the LAS SE1 STAR at ST168. The restrictions and fixes are depicted in Figure 8.

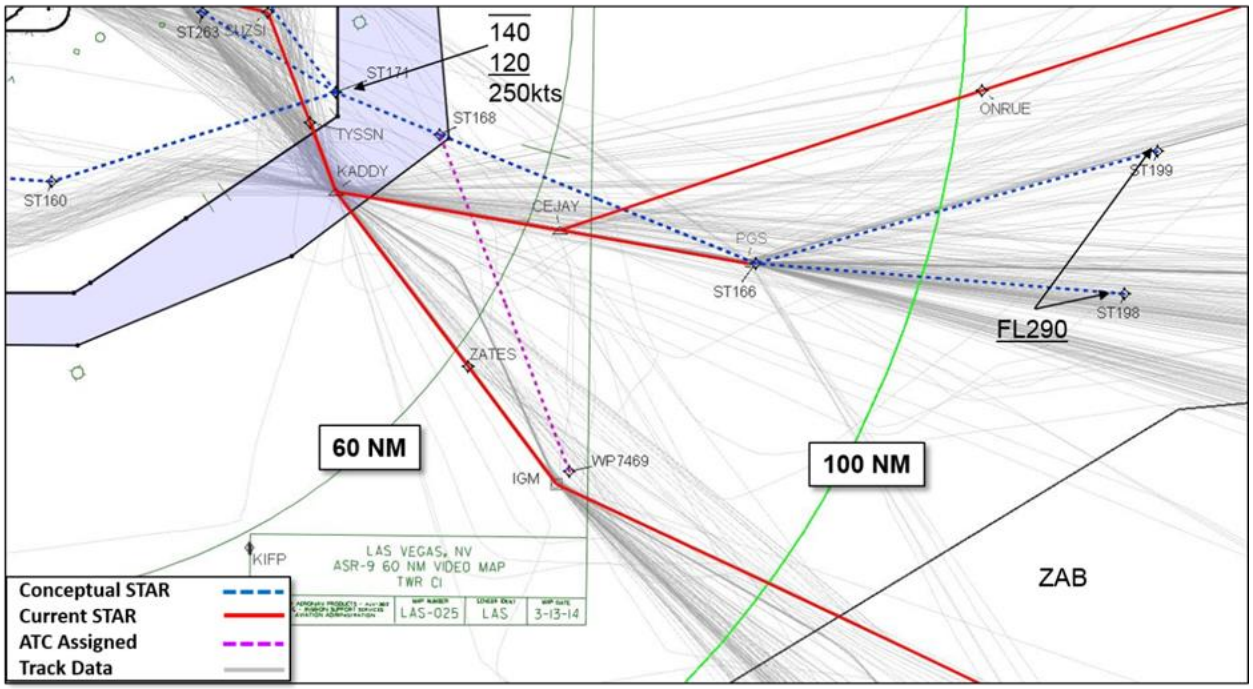

Figure 8. TYSSN STAR and LAS SE1 STAR En Route View

Waypoint ST168 was placed at the L30 conceptual boundary to facilitate a timely issuance of a runway transition. Runway transitions begin at ST171 and altitude windows were established at specific waypoints to optimize and deconflict the procedure for all configurations. The Las Vegas MST redesigned the Runways 19L/R transitions to merge with the LAS 1STAR at DUBLX. The restrictions and waypoints are depicted in Figure 9. All runway transitions were merged with current and proposed SIAPs.

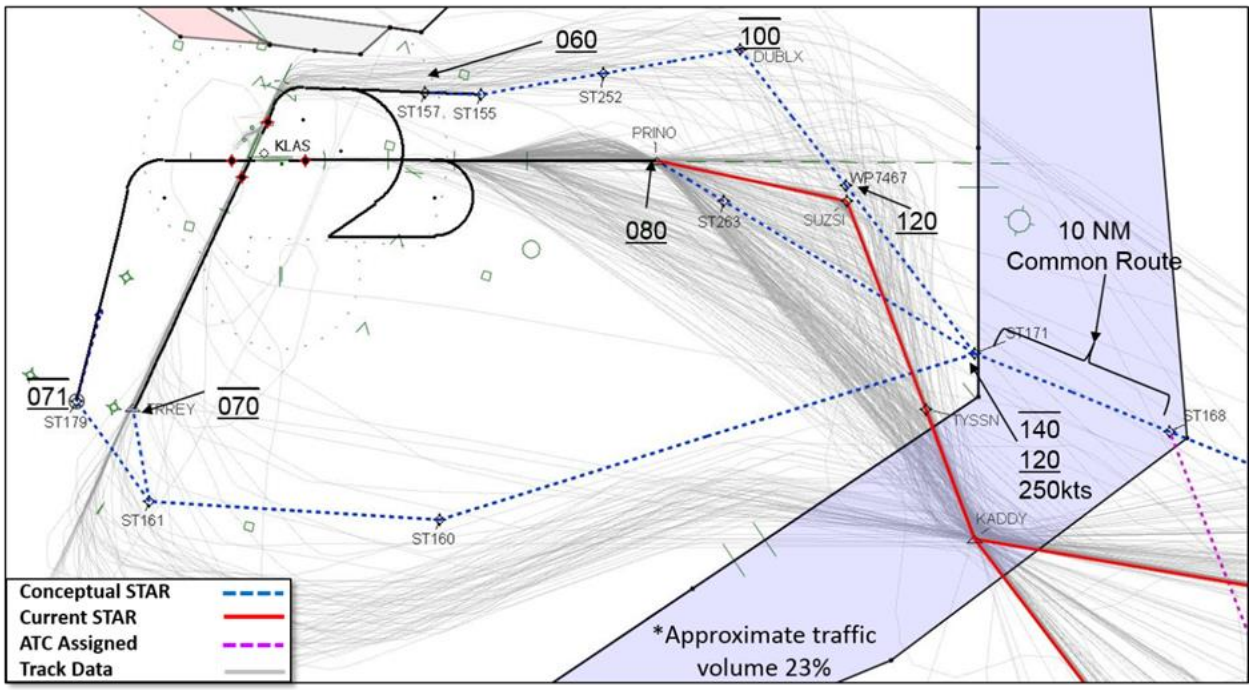

Figure 9. TYSSN STAR and LAS SE1 STAR Terminal View

Qualitative Benefits

The LAS SE1 STAR was designed for repeatable, predictable course guidance for all configurations with connectivity to proposed and current SIAPs. By optimizing the procedure, there should be an overall reduction in phraseology and the number of pilot/controller transmissions which will reduce task complexity and readback/hearback errors.

The LAS SE1 STAR route was designed to minimize interaction between the arrival and departure flows in the en route environment. In the terminal environment, this STAR is procedurally deconflicted from all conceptual SIDs.

Quantitative Benefits

The Las Vegas MST reduced lateral track miles by reviewing historical flight track data and designing more direct routes. By optimizing the vertical profile after the TOD, the LAS SE1 STAR reduces time and distance in level flight. These benefits result in a reduction in fuel burn and carbon emissions. Projected annual savings for the proposed LAS SE1 STAR are estimated in Table 6.

Table 6. Estimated Annual Savings for LAS SEI STAR

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS SE1 STAR	**853,000**	**$2,432,000**	**8,000**

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.1.3 LAS SE2 STAR

Issues

Stakeholders agree that the TYSSN STAR has numerous inefficiencies in its design. TYSSN arrivals incur approximately 15 to 20 NM level-offs at 12,000 feet and at 8,000 feet to comply with inefficient procedures. TYSSN STAR does not provide repeatable and predictable course guidance to runways other than Runways 25L/R. The lack of runway transitions requires controllers to vector aircraft to other runways increasing pilot/controller task complexity.

A sharp right turn at KADDY creates overtake situations at the L30/ZLA boundary. Currently, L30 controller's vector arrivals off the procedure to maintain in trail spacing. Two arrival transitions and the PRFUM SID all fly over KADDY requiring ZLA sectors to descend arrivals early to maintain vertical separation. The TYSSN STAR does not align with the proposed Phoenix Metroplex procedures.

Solutions

The Las Vegas MST created two RNAV OPD STARs (LAS SE1 STAR, LAS SE2 STAR) usable for all configurations which reduce overall flight track miles, minimize level segments and connect to current and proposed SIAPs. The dual STARs in the southeast quadrant may require the use of TBFM and an update to the TBFM adaptation. The LAS SE2 STAR incorporates altitude windows and speed constraints to reduce pilot/controller task complexity and readback/hearback errors.

The LAS SE2 STAR was designed to be used for traffic flying to western Mexico, Phoenix and Tucson area airports. The Las Vegas MST met with the Phoenix Metroplex leads and discussed connectivity to the Phoenix Metroplex proposals. The Phoenix Metroplex leads provided input that the LLUCK waypoint could be slightly moved without impacting their designs. To address the dual arrival concerns the Las Vegas MST created an ATC assigned cross over transition that will allow for a single arrival flow when warranted (i.e., weather impacts or reduced arrival rates).

Route Description

The Las Vegas MST looked at multiple options to replace the TYSSN STAR. These options included the addition of altitude window constraints, realignment of current and additional runway and en route transitions. During the Second Outreach, L30 requested the Runway 19 transition be removed from the procedure.

The LAS SE2 STAR was designed with one en route transition to be used for western Mexico, Phoenix and Tucson area airports and is not reliant on ground based navigation. The LAS SE2 STAR begins at the new LLUCK waypoint with an altitude constraint of FL280. The en route

transition continues to ST230. The ATC assigned cross over transition from the LAS SE1 STAR that allows for a single arrival flow when warranted (i.e., weather impacts or reduced arrival rates). This route joins the LAS SE2 STAR at ST230. The restrictions and fixes are depicted in Figure 10.

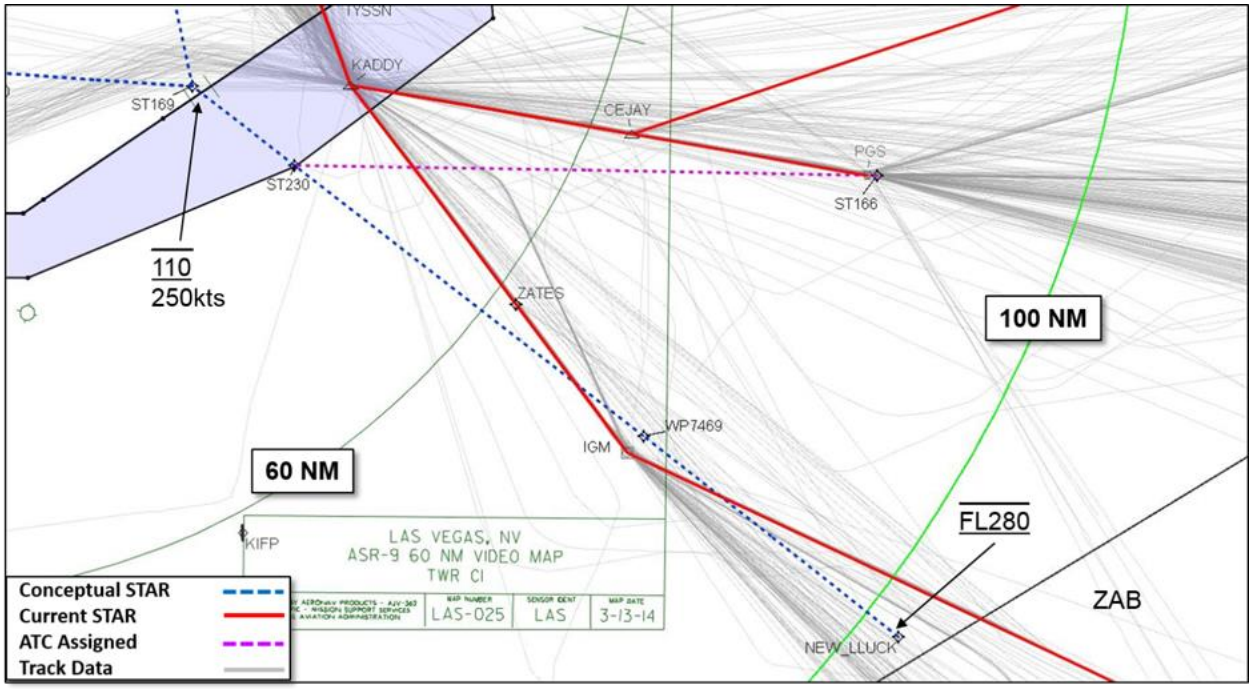

Figure 10. TYSSN STAR and LAS SE2 STAR En Route View

Waypoint ST230 was placed at the L30 conceptual boundary to facilitate a timely issuance of a runway transition. Runway transitions begin at ST169 and altitudes were established at specific waypoints to optimize and deconflict the procedure for all configurations. MST removed the Runways 19L/R transition from this STAR. The restrictions and waypoints are depicted in Figure 11. All runway transitions were merged with current and proposed SIAPs.

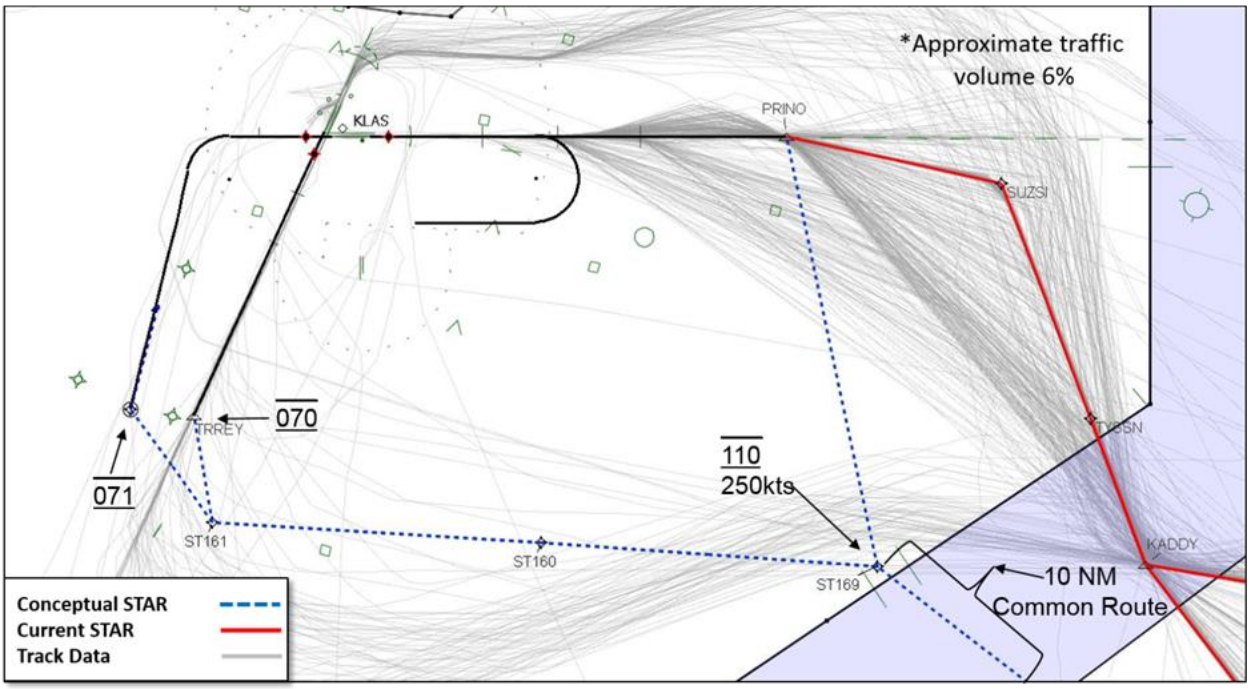

Figure 11. TYSSN STAR and LAS SE2 STAR Terminal View

Qualitative Benefits

The LAS SE2 STAR was designed for repeatable, predictable course guidance in all configurations with connectivity to proposed and current SIAPs. By optimizing the procedure, there should be an overall reduction in phraseology and the number of pilot/controller transmissions which will reduce task complexity and readback/hearback errors.

The LAS SE2 STAR route was designed to provide connectivity to the Phoenix Metroplex proposed procedures while minimizing interactions between the arrival and departure flows in the en route environment. In the terminal environment this STAR is procedurally deconflicted from all conceptual SIDs.

Quantitative Benefits

The LAS SE2 STAR was designed to provide better connectivity to the Phoenix Metroplex procedures. This design does have a slight increase in flight track miles, however, the conceptual LAS SE2 STAR provides many qualitative benefits and enhances safety by reducing the interactions between arrival and departure traffic. Projected annual savings for the conceptual LAS SE2 STAR are estimated in Table 7.

Table 7. Estimated Annual Savings for LAS SE2 STAR

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS SE2 STAR	**(153,000)**	**($437,000)**	**(1,400)**

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.1.4 LAS SW STAR

Issues

Stakeholder input indicates that the KEPEC STAR has numerous inefficiencies in its current design. KEPEC arrivals incur approximately 20 to 30 NM level-offs at FL240 and at 13,000 feet to comply with inefficient procedures. Aircraft have difficulty complying with speed and altitude restrictions landing Runways 01L/R. The STAR does not provide repeatable and predictable course guidance to runways other than Runways 25L/R. The lack of runway transitions requires controllers to vector aircraft to other runways increasing pilot/controller task complexity.

Solutions

The Las Vegas MST created an RNAV OPD STAR (LAS SW STAR) that is usable for all configurations which reduces overall flight track miles, minimizes level offs and connects to current and proposed SIAPs The LAS SW STAR utilizes altitude windows and speed restraints providing predictable and repeatable flight paths as well as reducing pilot/controller task complexity.

Route Description

The Las Vegas MST looked at multiple options to replace the KEPEC STAR. These options included altitude windows, realignment and addition of runway transitions, and realignment of the en route transitions. Due to the approximate 20 NM difference in track miles between “short side versus long side” arrivals, the Las Vegas MST discussed the possibility of using directional STARs in this quadrant. During the Second Outreach, L30 and ZLA preferred runway transitions over directional STARs.

The LAS SW STAR was designed with two en-route transitions. Both transitions utilize a window of FL290 to FL250 at TOD. The MISEN transition window will require ZLA to address current sectorization which is producing the lengthy level off at FL 240. Both transitions converge at ST186 with a window of FL190 to 13,000 feet. The window was proposed to optimize both short and long side arrivals. En route restrictions are depicted in Figure 12.

The conceptual procedure eliminates the sharp turn at SKEBR and routes arrivals via ST140, resulting in a significant savings in track miles. The Runway transitions begin at SKEBR, deconflict from departure traffic in all configurations, and tie into SIAPs. Terminal restrictions are depicted in Figure 13.

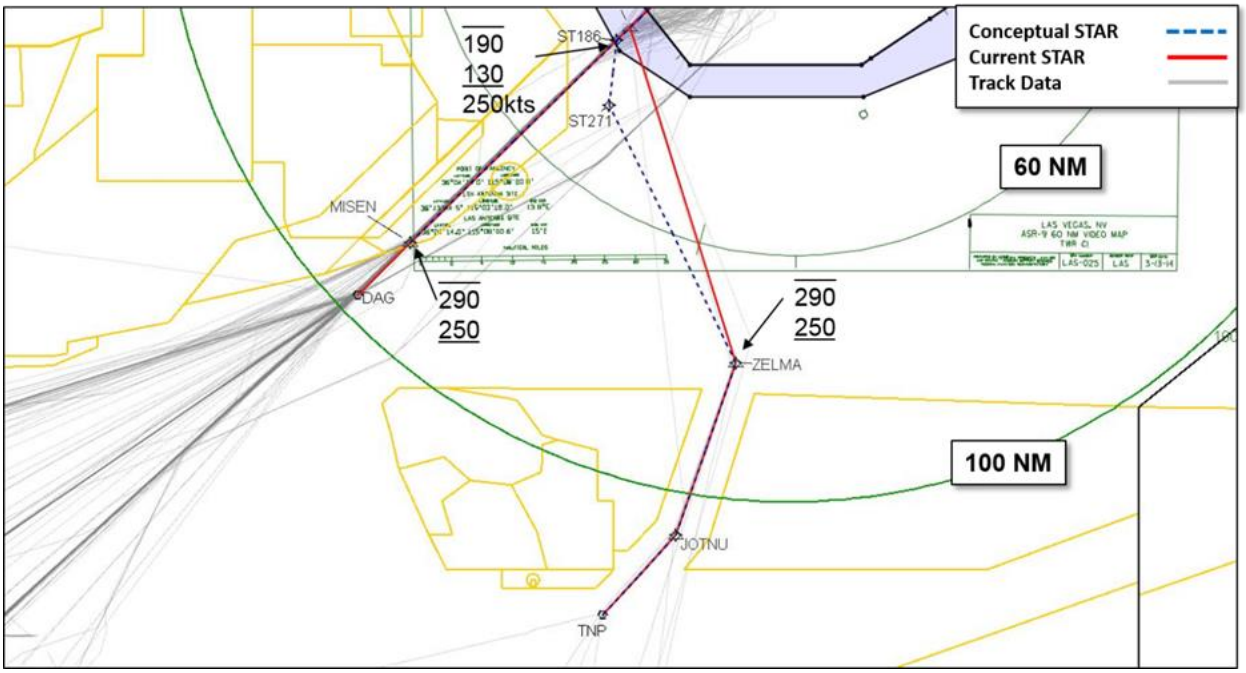

Figure 12. KEPEC STAR and the LAS SW STAR En Route View

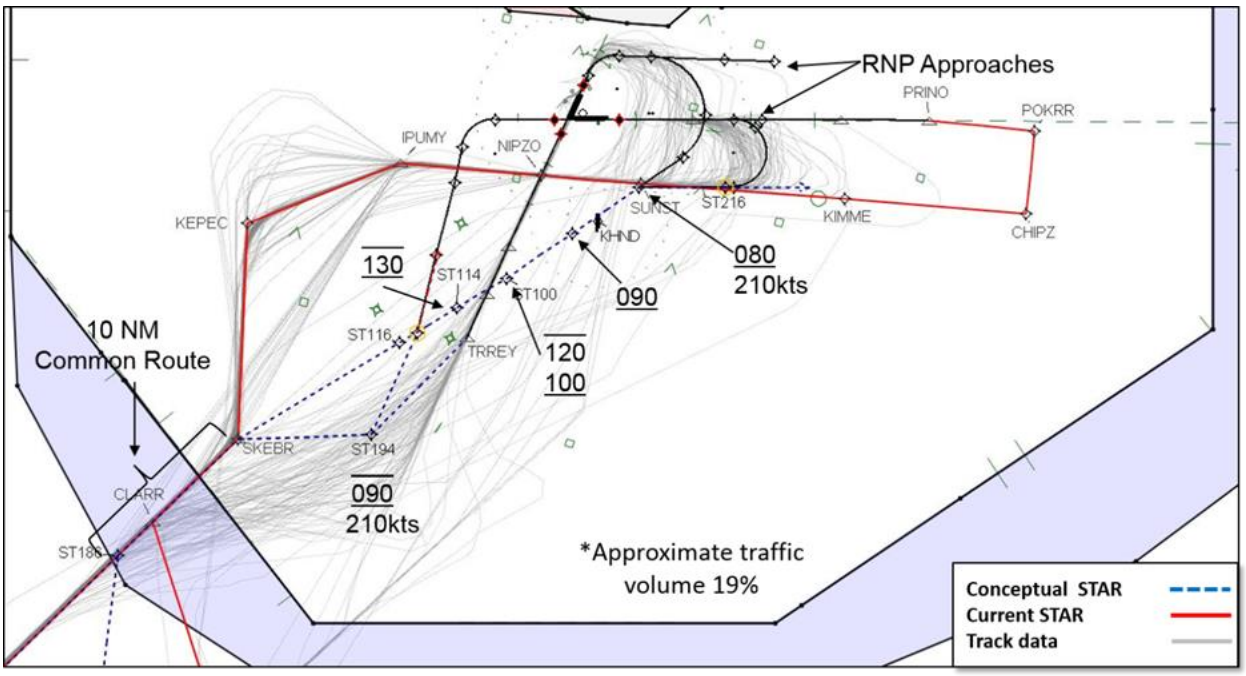

Figure 13. KEPEC STAR and the LAS SW STAR Terminal View

Qualitative Benefits

The LAS SW STAR was designed for repeatable, predictable course guidance in all configurations with connectivity to proposed and current SIAPs. By optimizing the procedure,

there should be an overall reduction in phraseology and the number of pilot/controller transmissions which will reduce task complexity and readback/hearback errors.

The LAS SW STAR route was designed to minimize interaction in the en route environment between the arrival and departure flows. In the terminal environment this STAR is procedurally deconflicted from all conceptual SIDs.

Quantitative Benefits

The Las Vegas MST reduced lateral track miles by reviewing historical flight track data and designing more direct routes. By optimizing the vertical profile after the TOD, the LAS SW STAR reduces time and distance in level flight. These benefits result in a reduction in fuel burn and carbon emissions. Projected annual savings for the proposed LAS SW STAR are estimated in Table 8.

Table 8. Estimated Annual Savings for LAS SW STAR

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS SW STAR	**793,000**	**$2,260,000**	**7,500**

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.1.5 LAS NW STAR

Issues

Stakeholder input indicates that the SUNST STAR has numerous inefficiencies in its current design. SUNST arrivals incur approximately 15 to 20 NM level-off at 16,000 feet and a 5 to 10 NM level off at 11,000 feet to comply with inefficient procedures. The SUNST STAR does not provide repeatable and predictable course guidance to runways other than Runways 25L/R. The lack of runway transitions requires controllers to vector aircraft to other runways increasing pilot/controller task complexity.

The SUNST STAR requires aircraft to cross MYCAL at or above FL210, making it difficult for arrival aircraft to meet speed and altitude restrictions at FUZZY.

The current Q-Route structure in ZLA Sector 16 does not provide necessary connectivity when considering the arrival, departure and overflight route structure.

Solutions

The Las Vegas MST originally proposed an alternative design for the northwest arrival/departure corridor showing a conceptual SID and STAR that reversed the arrival/departure flows in the northwest corridor. Initial designs of the SID in this quadrant had climb gradient concerns and needed further exploration. During the Second Outreach, ZLA and L30 provided feedback indicating they would prefer this alternative design as the primary proposal if feasible.

The Las Vegas MST was able to address these concerns by making the reverse flow alternative the primary recommendation. The RNAV OPD STAR (LAS NW STAR) is usable for all configuration, reduces level segments, and connects to current and proposed SIAPs. The LAS

NW STAR provides connectivity to the current Q-Route structure and incorporates altitude windows and speed assignments to reduce pilot/controller task complexity.

Reversing the arrival and departure flow in the northwest corridor provides aircraft on the LAS NW STAR additional track miles for an optimal descent. The reversal of flows has also removed interaction with the LAS NW SID (Section 4.3.2.6).

Route Description

The LAS NW STAR was designed with one en route transition which is not reliant on ground based navigation and provides connectivity to the Q-Route structure. The LAS NW STAR closely follows the lateral path of the SHEAD SID and is laterally segregated from Special Use Airspace (SUA) to the west and the LAS NW SID to the east.

At waypoint ST133 there is an altitude restriction to cross at or above FL210 to ensure clearance of NATCF airspace. At waypoint ST135 there is a crossing restriction of at or above 16,000 and 250 knots which is near the L30 airspace boundary. The restrictions and fixes are depicted in Figure 14.

Waypoint ST135 was placed at the L30 boundary to facilitate a timely issuance of a runway transition by L30. Runway transitions begin at ST101 and are designed to all runways except Runways 19L/R. All transitions include altitude windows that were established at specific waypoints to optimize and deconflict the procedure for all configurations. The restrictions and waypoints are depicted in Figure 15.

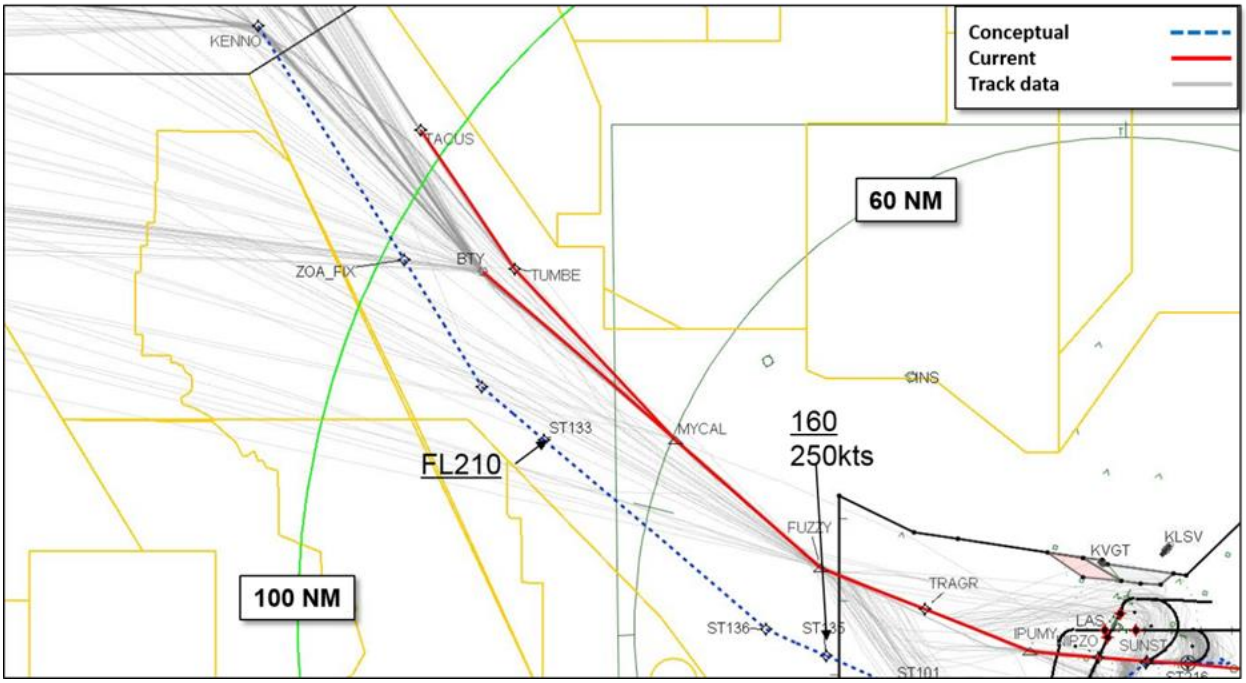

Figure 14. SUNST STAR and the LAS NW START En Route View

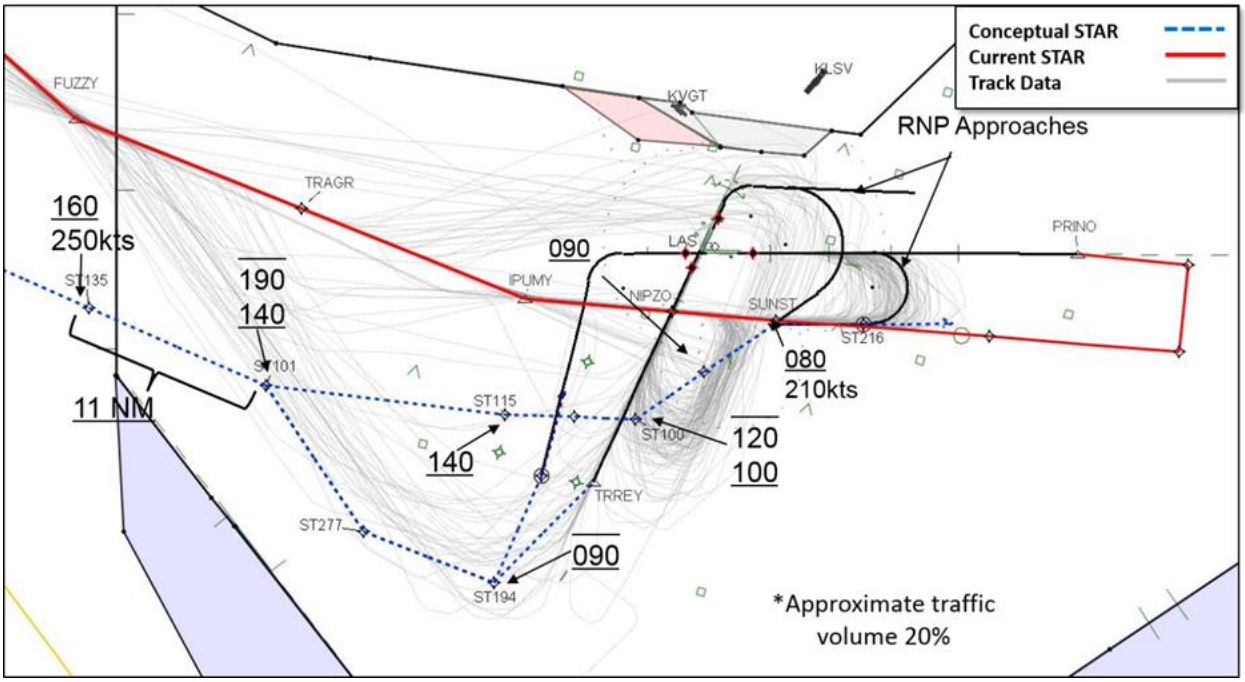

Figure 15. SUNST STAR and the LAS NW START Terminal View

Qualitative Benefits

The LAS NW STAR was designed for repeatable, predictable course guidance for all configurations with connectivity to SIAPs. By optimizing the procedure, there should be an overall reduction in phraseology and the number of pilot/controller transmissions which will reduce task complexity and readback/hearback errors.

The reversal of the arrival and departure flows in the northwest corridor allowed the Las Vegas MST to design the LAS NW STAR with minimal interactions in the en route environment between the arrivals, departures, and overflights. In the terminal environment, this STAR is procedurally deconflicted from all conceptual SIDs and all interaction with the LAS NW SID is eliminated.

Quantitative Benefits

The flow reversal increased lateral track miles for the LAS NW STAR; however, this increase is offset by a significant decrease in lateral track miles on the LAS NW SID (Section 4.3.2.6). By optimizing the vertical profile after TOD, the LAS NW STAR reduces time and distance in level flight. After analysis, the increase in track miles and decrease in level-offs result in a disbenefit. The estimated annual savings for the LAS NW STAR are shown in Table 9.

Table 9. Estimated Annual Savings for LAS NW STAR

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS NW STAR	(176,000)	($501,000)	(1,700)

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.1.6 Summary of Potential Benefits for LAS Conceptual STARs

As shown in Table 10 the proposed LAS STARs are estimated to produce over $6 million annually in fuel savings and a reduction of 19,800 metric tons in carbon emissions.

Table 10. LAS Conceptual Arrivals: Summary of Estimated Annual Savings

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
NW/SUNST	(176,000)	($501,000)	(1,700)
SW/KEPEC	793,000	$2,260,000	7,500
SE2/TYSSN-PHOENIX	(153,000)	($437,000)	(1,400)
SE1/TYSSN-PGS	853,000	$2,432,000	8,000
NE/GRNPA	794,000	$2,263,000	7,500
TOTAL**	2,111,000	$6,017,000	19,800

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.2 LAS Departures

This section describes the operational issues, solutions, and expected benefits the Las Vegas MST has identified for LAS departures. All procedures were designed with safety as the primary consideration.

4.3.2.1 LAS NE1 SID

Issues

The STAAV SID is available in configuration 1 for Runways 25L/R only. Stakeholders request that the STAAV SID be available for all configurations. Departures assigned the TRALR SID MLF transition turn into the path of arrivals. Facilities requested that the Las Vegas MST merge conceptual designs with Southern California Metroplex procedures and provide Q-Route connectivity.

Stakeholders reported the current procedure has high climb gradients and several aircraft types have trouble meeting the STAAV and FOLDD restrictions. The NATCF identified a lack of a northbound transition through the Nellis SUA, when the airspace is available for joint use.

Solutions

The Las Vegas MST created an RNAV SID (LAS NE1 SID) usable for all configurations which reduces flight track miles, and connects to the proposed Southern California Metroplex procedures. The LAS NE1 SID was designed to add transitions off all runways and simplify departure flows with two en route transitions. One transition ends at the proposed Southern California Metroplex waypoint WINEN. The Las Vegas MST designed an ATC assigned transition over CRITO that traverses the Nellis SUA when the airspace is open for joint use.

LAS NE1 SID incorporates lower altitude restrictions which reduce climb gradients. This procedure allows jet aircraft to meet conceptual altitudes, reducing pilot/controller task complexity and increase efficiencies. Las Vegas MST designed the LAS NE1 SID to be deconflicted from conceptual STARs.

Route Description

During procedure design, the Las Vegas MST looked at multiple options to replace the current STAAV SID. These options included realignment of runway transitions and creation of additional runway transitions. The new transitions include various altitude constraints with simplified en route transitions. During the Second Outreach L30 requested that runway transitions be added for Runways 07L/R and requested that Runways 01L/R departures be modified to an initial right turn.

As depicted in Figures 16 and 17, the current procedure has three en route transitions. The LAS NE1 SID has two en route transitions, one over WINEN and the other is an ATC assigned over CRITO. The availability of the LAS NE1 SID for all configurations and serving all northbound departure traffic eliminates the need for the TRALR MLF transition. The proposed SID utilizes lower altitude constraints allowing reduced climb gradients for turbojet departures. Restrictions, fixes, and transitions are depicted in Figures 16 and Figure 17.

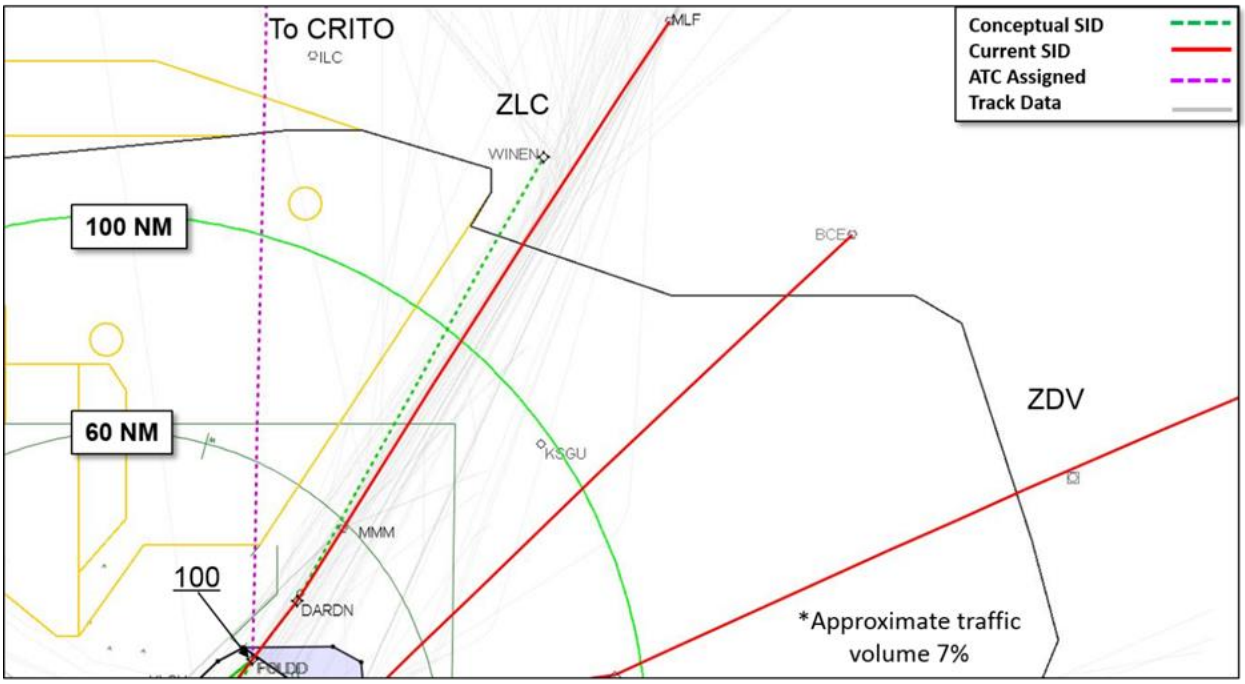

Figure 16. STAAV SID and the LAS NE1 SID Terminal View

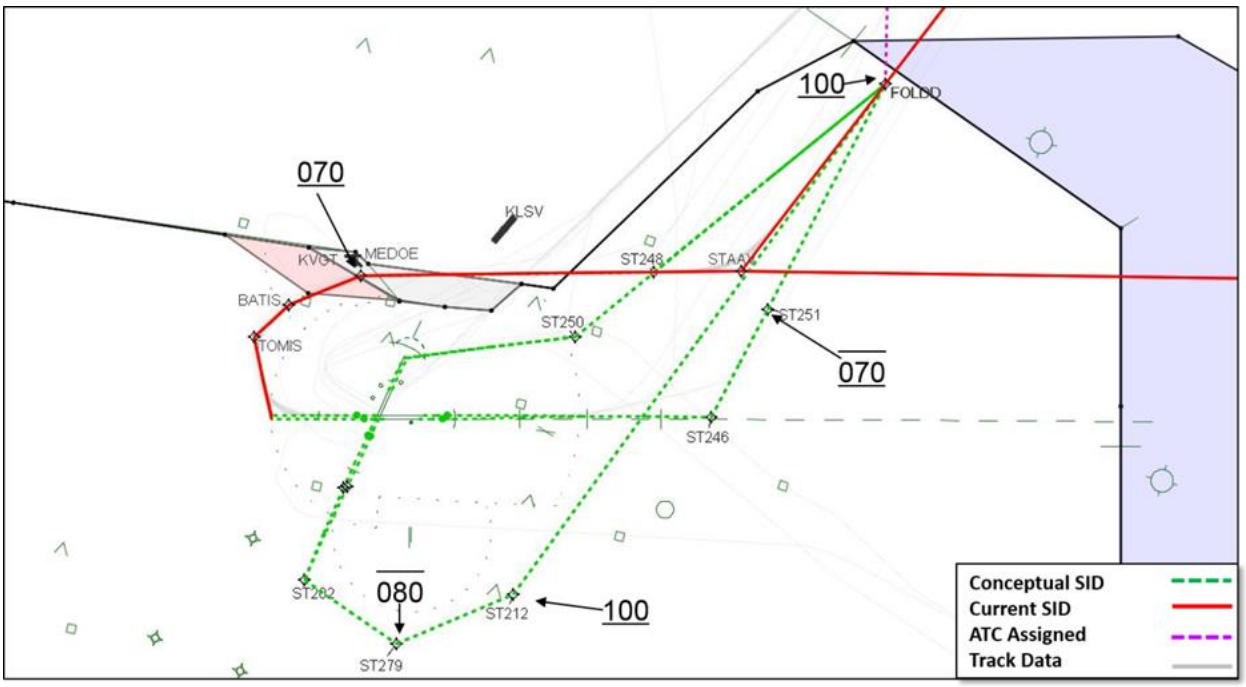

Figure 17. STAAV SID and the LAS NE1 SID En Route View

Qualitative Benefits

The LAS NE1 SID was procedurally deconflicted from all conceptual MST STARs in the terminal environment and was designed to minimize interaction between the departure and arrival flows in the en route environment. The LAS NE1 SID was designed for repeatable, predictable course guidance for all configurations with connectivity to proposed Q-Routes. By optimizing the procedure, safety is enhanced by reducing task complexity, phraseology, the number of pilot/controller transmissions, and readback/hearback errors.

Quantitative Benefits

The Las Vegas MST reduced lateral track miles by reviewing historical flight track data and designing more direct routes. To deconflict the Runways 25L/R and 19L/R departures from the Las Vegas MST conceptual STARs, altitude constraints were required. During analysis, altitude constraints were applied to 20 percent of all departures. This conservative estimate was based on a controller's ability to dynamically separate departure aircraft from arrival aircraft. Projected annual savings for the proposed LAS NE1 SID are estimated in Table 11.

Table 11. Estimated Annual Savings for LAS NE1 SID

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS NE1 SID	**43,000**	**$122,000**	**400**

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.2.2 LAS NE2 SID

Issues

The TRALR SID is available for all configurations with Runways 25L/R and 19L/R traffic merging close to the airport over ROPPR, increasing ATC task complexity. Stakeholders identified an issue with confusion between filed routes and assigned routes, and requested a new SID that mimics the right turn on the STAAV SID. ZLA identified the TRALR SID MLF transition conflicts with the GRNPA STAR. The TRALR SID has inefficient initial departure routes and altitudes. ZLA requested that all conceptual designs merge with Southern California Metroplex designs and have Q-Route connectivity.

Solutions

The Las Vegas MST reduced lateral track miles by reviewing historical flight track data and designing more direct routes, created an RNAV SID (LAS NE2 SID) usable for all configurations which reduces flight track miles, and connects to the proposed Southern California Metroplex procedures. LAS NE2 SID was designed with runway transitions for all configurations and simplifies departure flows with two en route transitions, one ending at the proposed Southern California Metroplex waypoint VERKN (BCE area) and the other at WP7458 (replaces DVC transition). Both transitions join Southern California Metroplex proposed Q-Routes.

The LAS NE2 SID segregates Runways 19L/R departure routes from ROPPR and optimizes lateral paths and vertical profiles. To eliminate the confusion between filed routes and assigned routes, the conceptual procedure mimics the initial path of the Runways 25L/R transition of the LAS NE1 SID. The LAS NE2 SID en route transitions minimize the conflictions with the conceptual LAS NE STAR.

Route Description

During procedure design, the Las Vegas MST looked at multiple options to replace the current TRALR SID. The options included various altitude constraints, realignment of runway transitions, and simplifying en route transitions. As depicted in Figures 18 and 19, the current procedure has three en route transitions. The LAS NE2 SID has two en route transitions over the BCE and DVC areas. During the Second Outreach, ZLA requested that the two en route transitions be moved to points more in line with proposed Southern California Metroplex designed routes.

The LAS NE2 SID was designed to be available for all configurations and is not reliant on ground based navigation. The LAS NE2 SID provides transitions for runways and simplifies departure flows with two en route transitions, one over VERKN (BCE) and a transition over WP7458 (DVC). The proposed SID utilizes lower altitudes with reduced climb gradients. Restrictions, fixes and transitions are depicted in Figures 18 and Figure 19.

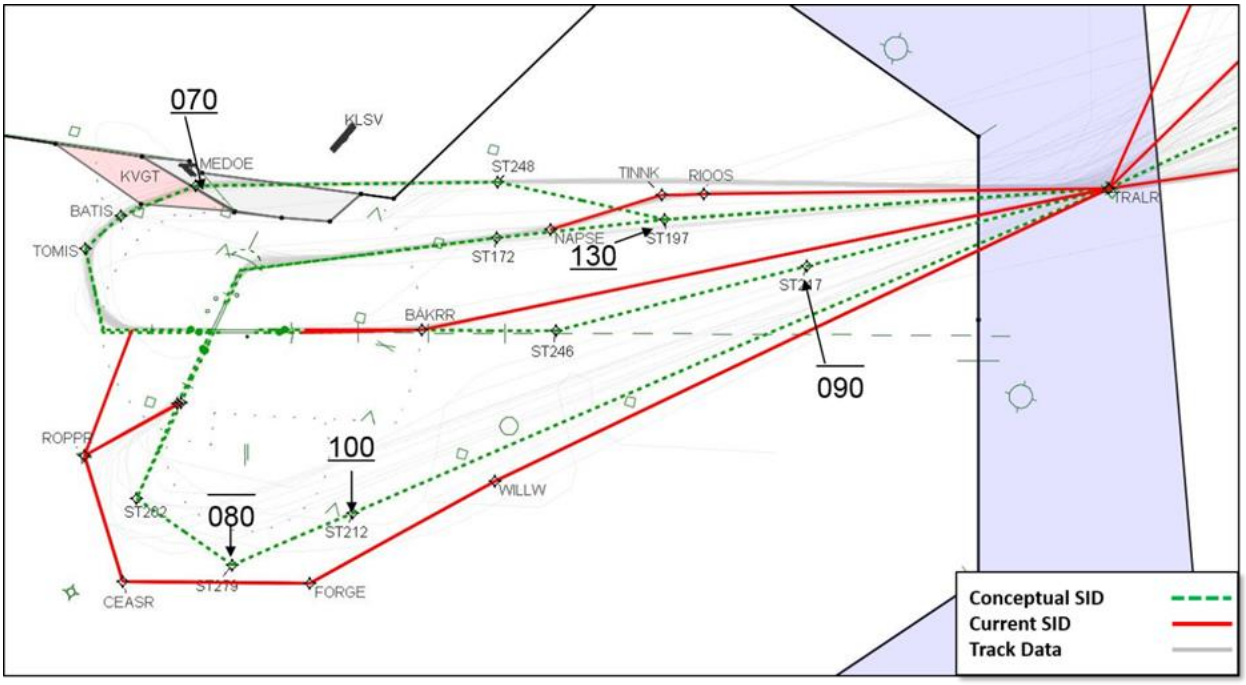

Figure 18. TRALR SID and the LAS NE2 SID Terminal View

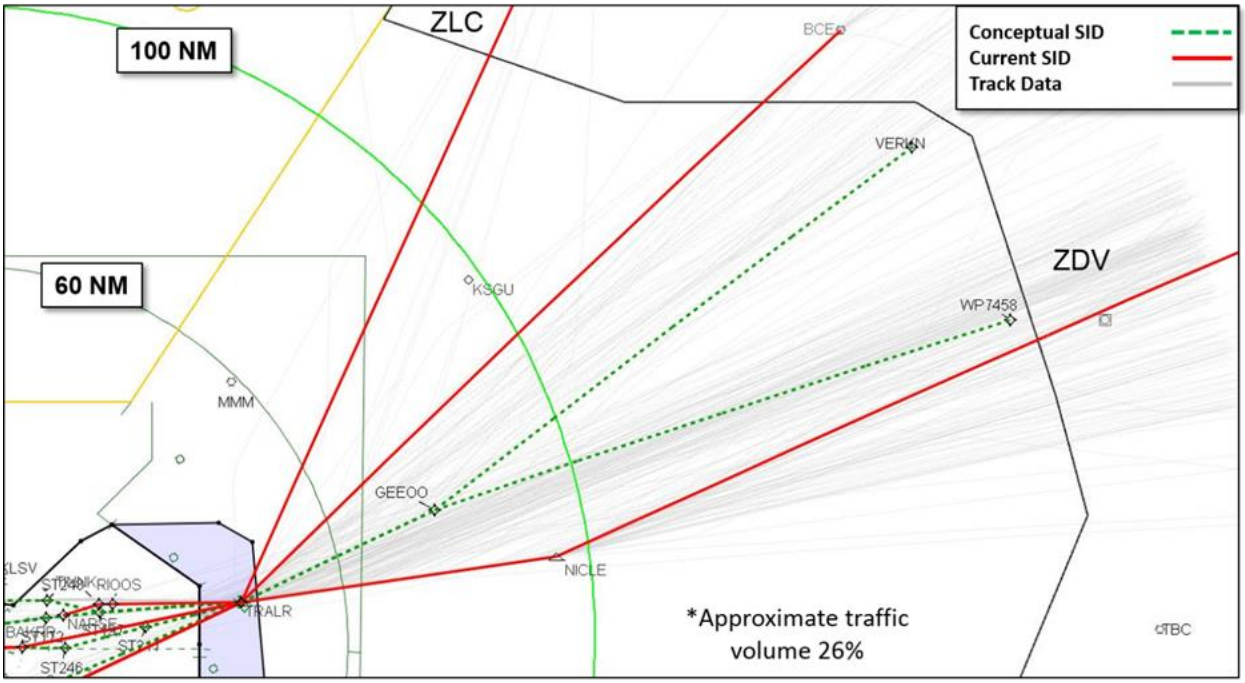

Figure 19. TRALR SID and the LAS NE2 SID En Route View

Qualitative Benefits

The LAS NE2 SID was procedurally deconflicted from all conceptual MST STARs in the terminal environment and was designed to minimize interaction between the departure and arrival flows in the en route environment. The LAS NE2 SID was designed for repeatable, predictable course guidance for all configurations with connectivity to proposed Q-Routes. By optimizing the procedure, safety is enhanced by reducing task complexity, phraseology, the number of pilot/controller transmissions, and readback/hearback errors.

Quantitative Benefits

With less reliance on ground based navigation, the Las Vegas MST was able to mimic current lateral track data. To deconflict the Runways 25L/R and 19L/R departures from the Las Vegas MST conceptual STARs, altitude constraints were required. During analysis, altitude constraints were applied to 20 percent of all departures. This conservative estimate was based on a controller's ability to dynamically separate departure aircraft from arrival aircraft. Projected annual savings for the proposed LAS NE2 SID are estimated in Table 12.

Table 12. Estimated Annual Savings for LAS NE2 SID

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS NE2 SID	**(11,000)**	**($31,000)**	**(100)**

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.2.3 LAS SE1 SID

Issues

The COWBY SID is available for all configurations; however aircraft departing Runways 19L/R and Runways 25L/R have an inefficient initial altitude constraint and merge close to the airport over ROPPR, increasing ATC task complexity.

The COWBY SID is not deconflicted from the TYSSN STAR. The COWBY SID lacks connectivity with the proposed Phoenix Metroplex procedures. L30 and ZLA requested that a weather mitigation route be developed for aircraft departing LAS to the northeast when the TRALR SID is not usable.

Solutions

The Las Vegas MST developed an RNAV SID (LAS SE1 SID) usable in all configurations which optimizes lateral paths and connects to the proposed Phoenix Metroplex procedures. The LAS SE1 SID incorporates altitude and speed restrictions to reduce pilot/controller task complexity and increases efficiencies. The LAS SE1 SID was deconflicted from conceptual STARs. The Las Vegas MST created an ATC assigned transition to the northeast to be used whenever the LAS NE2 SID is unavailable.

Route Description

The Las Vegas MST reviewed multiple options to replace the COWBY SID. During procedure design the Las Vegas MST reviewed historical flight track data and designed more efficient routes. Options included various altitude constraints and realignment of runway transitions. The LAS SE2 SID eliminated the need for the BZARO transition; however, during the Second Outreach, ZLA requested to keep the BZARO transition for airports other than Phoenix.

The LAS SE1 SID was designed to be available for all configurations and is not reliant on ground based navigation. In the terminal environment, the LAS SE1 SID is deconflicted from conceptual STARs. Three en route transitions were created, one to the east (ST174) and two to the southeast (ST175 and BZARO). The BZARO transition connects with the proposed Phoenix Metroplex procedures. An ATC assigned transition was created to the northeast to be used when the LAS NE2 SID is unavailable. The restrictions and fixes are depicted in Figures 20 and 21.

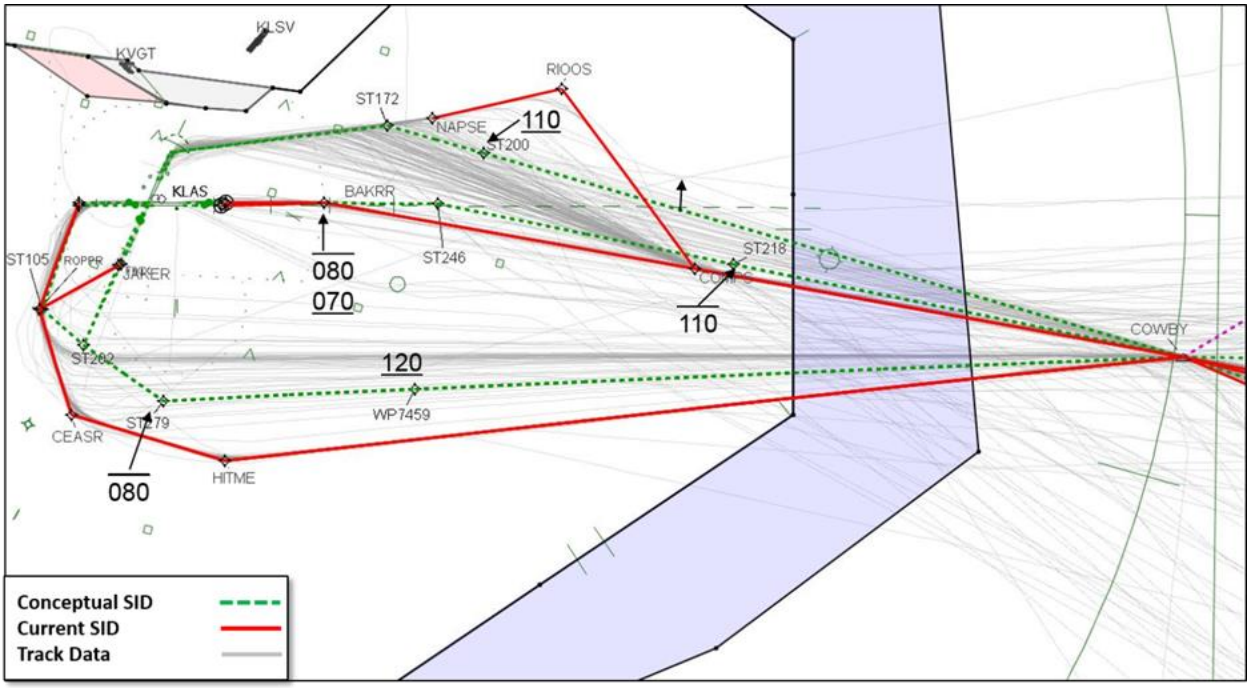

Figure 20. COWBY SID and the LAS SE1 SID Terminal View

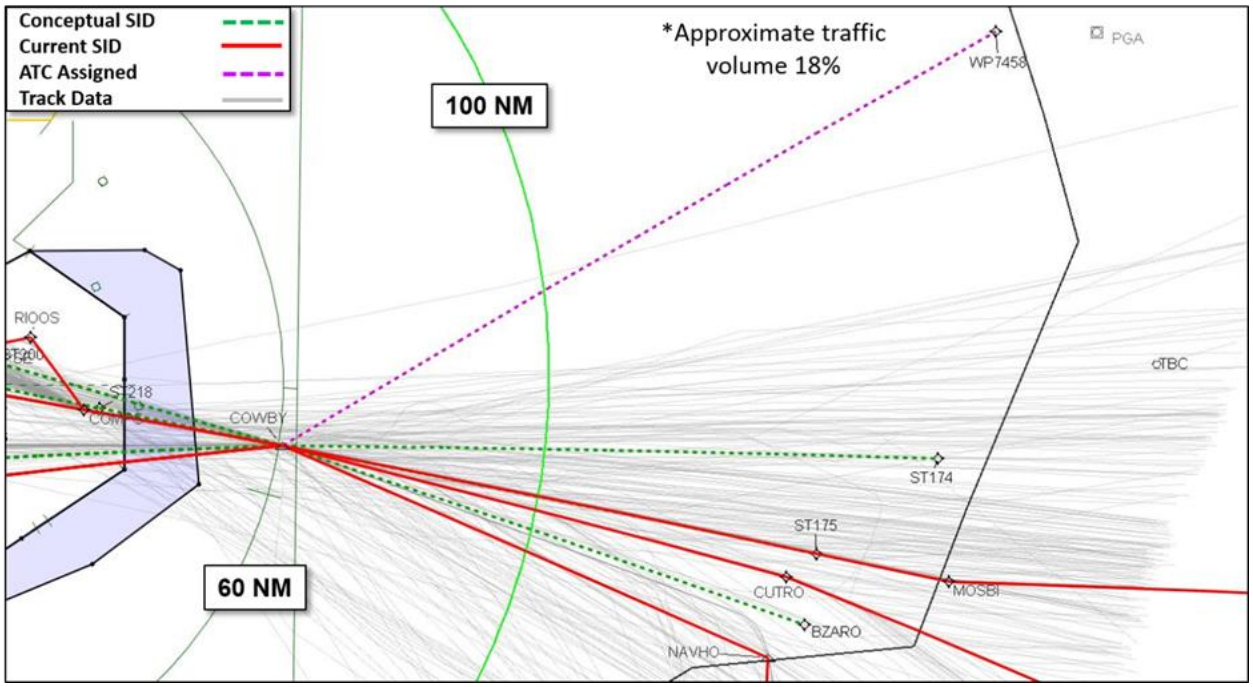

Figure 21. COWBY SID and the LAS SE1 SID En Route View

Qualitative Benefits

The LAS SE1 SID was procedurally deconflicted from all conceptual MST STARs in the terminal environment and was designed to minimize interaction between the departure and arrival flows in the en route environment. The LAS SE1 SID was designed for repeatable, predictable course guidance for all configurations. By optimizing the procedure, safety is enhanced by reducing task complexity, phraseology, the number of pilot/controller transmissions, and readback/hearback errors.

Quantitative Benefits

Additional flight track miles were required to connect with the proposed Phoenix Metroplex procedures. To deconflict the Runways 25L/R and 19L/R departures from the Las Vegas MST conceptual STARs, altitude restrictions were required. During analysis, altitude restrictions were applied to 20 percent of all departures. This conservative estimate was based on a controller's ability to dynamically separate departure aircraft from arrival aircraft. Projected annual savings for the proposed LAS SE1 SID are estimated in Table 13.

Table 13. Estimated Annual Savings for LAS SE1 SID

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS SE1 SID	(173,000)	($494,000)	(1,600)

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.2.4 LAS SE2 SID

Issues

The PRFUM SID is available in Configuration 1 only. Stakeholders requested availability of the PRFUM SID for all configurations. Aircraft departing Runways 19L/R and Runways 25L/R have an inefficient initial altitude constraint and merge close to the airport over ROPPR, increasing ATC task complexity.

The PRFUM SID conflicts with the TYSSN STAR at KADDY and does not align with the proposed Phoenix Metroplex procedures.

Solutions

The Las Vegas MST created the LAS SE2 SID which is usable for all configurations and connects to the proposed Phoenix Metroplex procedures. The LAS SE2 SID incorporates altitude and speed constraints to reduce pilot/controller task complexity and increases efficiencies. The LAS SE2 SID was designed to be deconflicted from conceptual STARs.

Route Description

During procedure design, the Las Vegas MST looked at multiple options to replace the PRFUM SID. These options included realignment of runway transitions and creation of additional runway transitions. The original design incorporated a left turn off Runway 01L/R and did not include a

Runway 07L/R transition. During the Second Outreach, Las Vegas Air Traffic Control Tower (LAS ATCT) requested that runway transitions be added for Runways 07L/R. L30 requested the Runway 01L/R transition be modified to turn right in lieu of the original MST proposed left turn southbound. The new transitions include various altitude constraints with simplified en route transitions.

The LAS SE2 SID was designed to be available for all configurations and is not reliant on ground based navigation. The SID has one en route transition that ends at LEEXX for connectivity to the Phoenix Metroplex procedures. In the terminal environment, the SID is deconflicted from all conceptual STARs. In the en route environment, the LAS SE2 SID is segregated from the southeast STARs except when ZLA utilizes the conceptual ATC assigned routing (see 4.3.1.2 and 4.3.1.3). The restrictions and fixes are depicted in Figures 22 and 23.

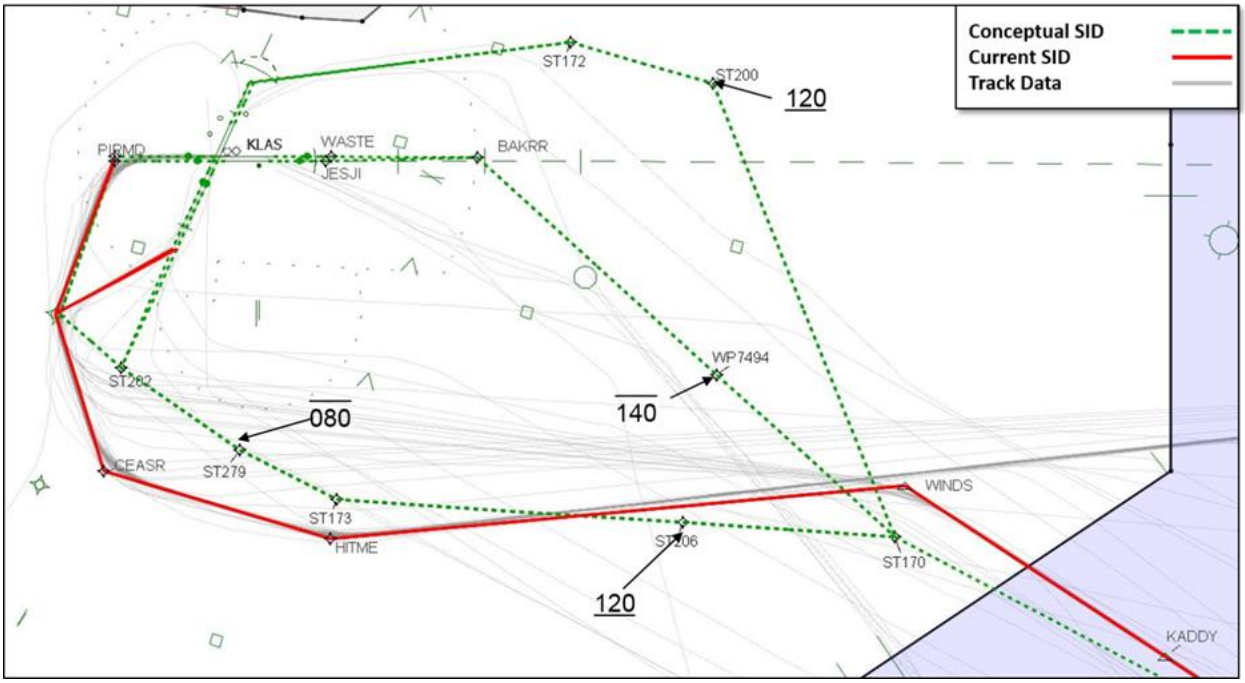

Figure 22. PRFUM SID and the LAS SE2 SID Terminal View

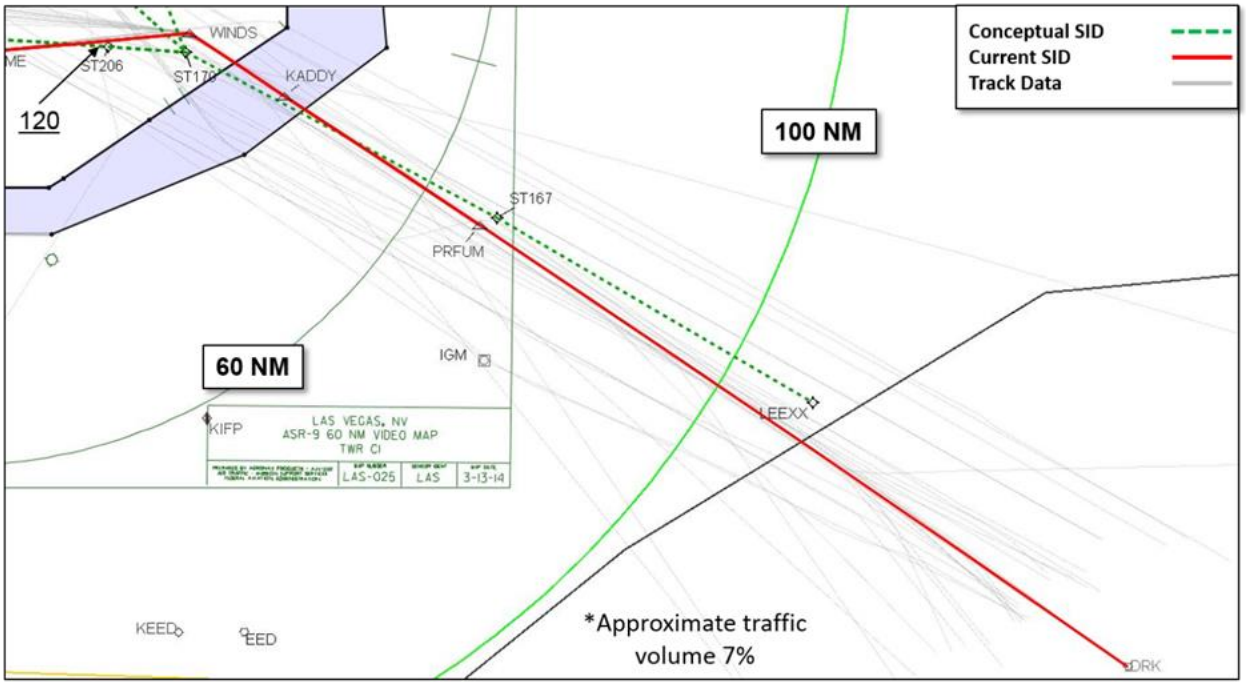

Figure 23. PRFUM SID and the LAS SE2 SID En Route View

Qualitative Benefits

The LAS SE2 SID was designed for repeatable, predictable course guidance for all configurations with connectivity to Phoenix Metroplex proposed procedures. By optimizing the procedure, safety is enhanced by reducing task complexity, phraseology, the number of pilot/controller transmissions, and readback/hearback errors.

The LAS SE2 SID was procedurally deconflicted from all conceptual STARs in the terminal environment and was designed to minimize interaction between the departure and arrival flows in the en route environment.

Quantitative Benefits

The Las Vegas MST reduced lateral track miles by reviewing historical flight track data and designing more direct routes. The LAS SE2 SID results in a positive benefit from a reduction in track miles in Configuration 3. To deconflict the Runways 25L/R and 19L/R departures from the conceptual STARs, altitude constraints were required. During analysis, altitude constraints were applied to 20 percent of all departures. This conservative estimate was based on a controller's ability to dynamically separate departure aircraft from arrival aircraft. Projected annual savings for the conceptual LAS SE2 SID are estimated in Table 14.

Table 14. Estimated Annual Savings LAS SE2 SID

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS SE2 SID	**11,000**	**$32,000**	**100**

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.2.5 LAS SW SID

Issues

Stakeholders agree that there are inefficiencies in the current design of the BOACH SID. Runways 25L/R and 19L/R departure traffic merge close to the airport over ROPPR and inefficient vertical profile which increase ATC task complexity.

Facilities requested the Las Vegas MST ensure that the conceptual design merges with Southern California Metroplex designs, have Q-Route connectivity, and provide a weather mitigation route.

Solutions

The Las Vegas MST created an RNAV SID (LAS SW SID) usable for all configurations which reduces flight track miles and connects to the proposed Southern California Metroplex procedures. The LAS SW SID was designed with transitions for all runways and simplifies departure flows with connectivity to the proposed Southern California Metroplex.

The LAS SW SID segregates Runways 19L/R departure routes from ROPPR and optimizes lateral paths and vertical profiles. A southeast bound weather mitigation transition was designed as an ATC assigned route.

Route Description

During procedure design the Las Vegas MST looked at multiple options to replace the current BOACH SID. These options included optimized vertical profiles, realigned runway transitions, and simplified en route transitions. As depicted in Figures 24 and 25, the conceptual procedure has two en route transitions one over OTOOL and the other over TNP. The OTOOL transition joins the Southern California Metroplex proposed procedures and Q-Routes.

The LAS SW SID was designed to be available for all configurations. In the terminal environment the LAS SW SID is deconflicted from the conceptual STARs. Restrictions, fixes, and transitions are depicted in Figures 24 and 25.

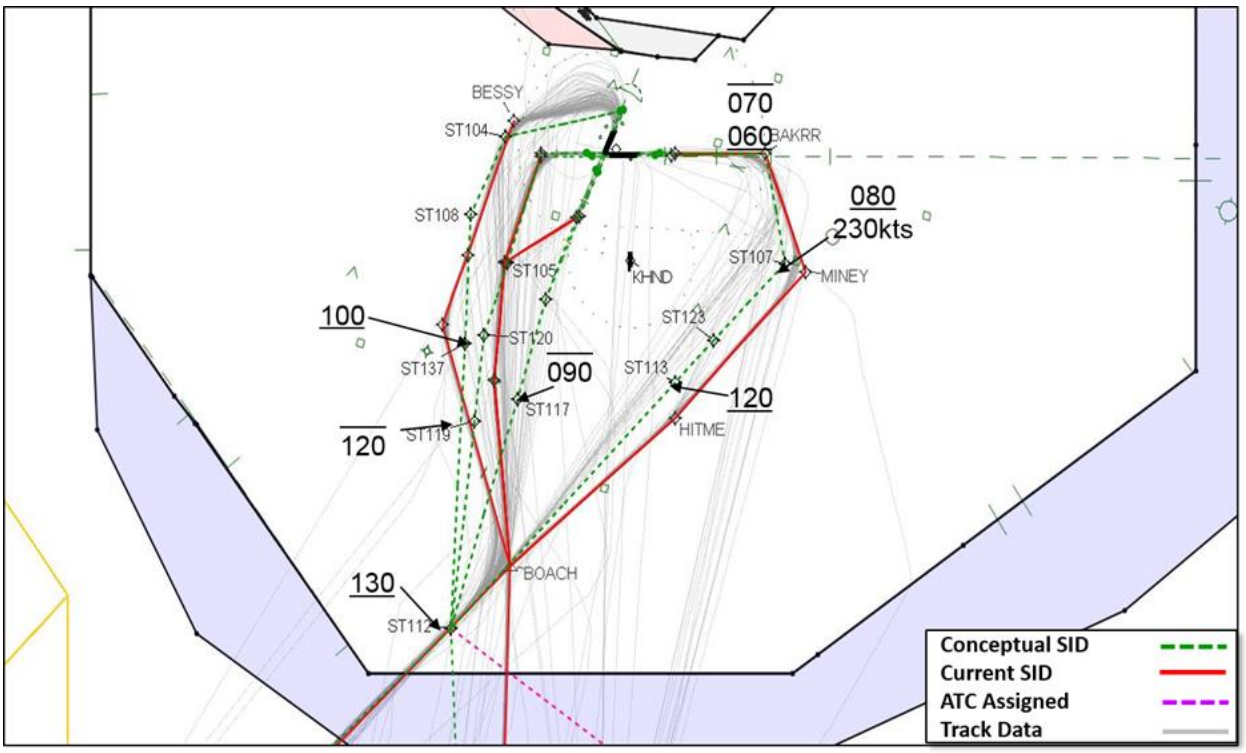

Figure 24. BOACH SID and the LAS SW SID Terminal View

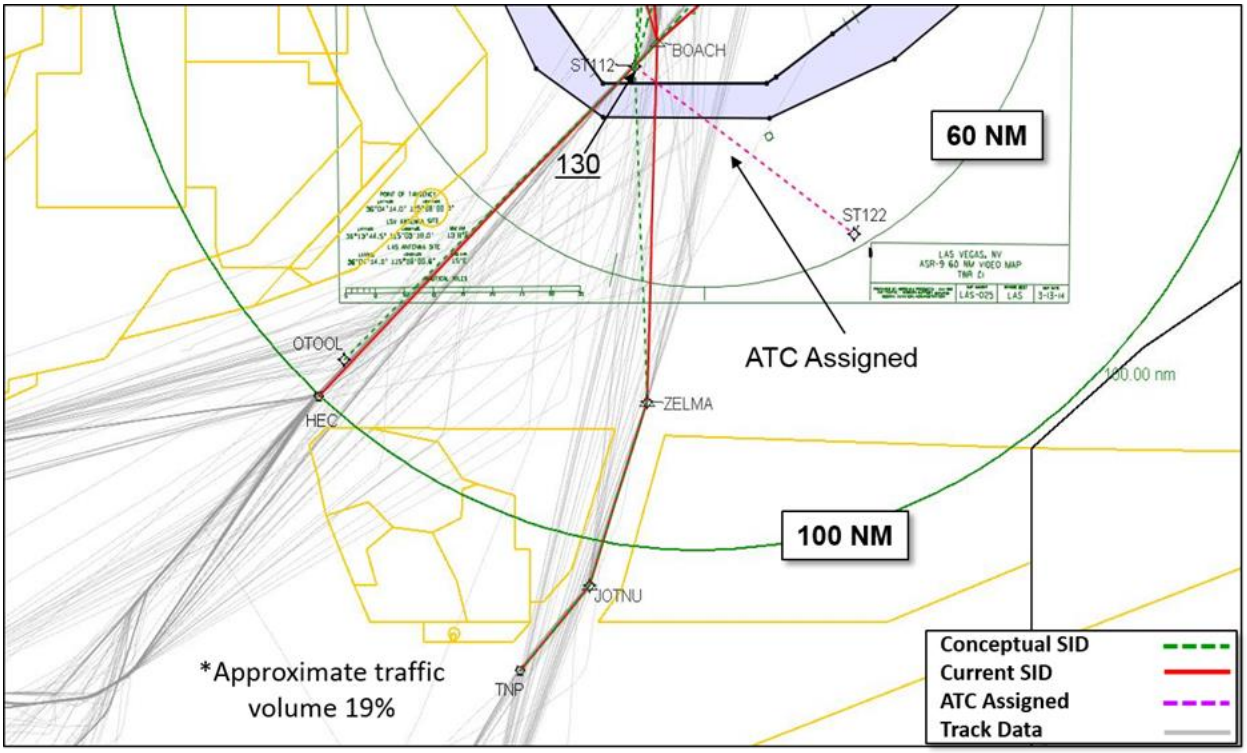

Figure 25. BOACH SID and the LAS SW SID En Route View

Qualitative Benefits

The LAS SW SID was procedurally deconflicted from all conceptual STARs in the terminal environment and was designed to minimize interaction between the departure and arrival flows in the en route environment. The LAS SW SID was designed for repeatable, predictable course guidance for all configurations with connectivity to proposed Q-Routes. By optimizing the procedure, safety is enhanced by reducing task complexity, phraseology, the number of pilot/controller transmissions, and readback/hearback errors.

Quantitative Benefits

The Las Vegas MST reduced lateral track miles by reviewing historical flight track data and designing more direct routes. The LAS SW SID results in a positive benefit from a reduction in track miles. To deconflict the Runways 25L/R and 19L/R departures from the conceptual STARs, altitude constraints were required. During analysis, altitude constraints were applied to 20 percent of all departures. This conservative estimate was based on a controller's ability to dynamically separate departure aircraft from arrival aircraft. Projected annual savings for the conceptual LAS SW SID are estimated in Table 15.

Table 15. Estimated Annual Savings for the LAS SW SID

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS SW SID	**86,000**	**$245,000**	**800**

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.2.6 LAS NW SID

Issues

The SHEAD SID is available for all configurations with Runways 25L/R and 19L/R traffic merging close to the airport over ROPPR increasing ATC task complexity. Stakeholders agree that there are inefficiencies in the design of the SHEAD SID. There are numerous interactions between arrival and departure flows to the northwest within terminal airspace creating level segments. Traffic on the SHEAD SID typically experiences approximately five NM of level flight at 7,000 and 9,000 feet and five to ten NM at 11,000 feet. In the en route environment, the current Q-Route structure in ZLA Sector 16 does not provide necessary connectivity. ZLA Sector 16 is a very narrow volume of airspace confined on the east and west by several SUAs.

The SHEAD SID requires a sharp turn at the SHEAD waypoint. The route is minimally segregated from the SHOSHONE SUA at this turn and some aircraft have difficulty with course guidance and possible incursion into the SUA. These deviations require ATC to coordinate with the DOD thus increasing controller task complexity and workload.

Solutions

Based on feedback from the facilities the Las Vegas MST reversed flows in the northwest corridor. Las Vegas MST created an RNAV SID (LAS NW SID) usable for all configurations.

The LAS NW SID provides connectivity to the current Q-Route structure (Q162/Q13 at TUMBE) and incorporates altitude and speed restrictions to reduce pilot/controller task complexity.

Reversing the arrival and departure flows in the northwest corridor provides aircraft on the LAS NW SID an unrestricted climb by removing all interaction with the northwest arrival traffic. By moving the departure route to the north and east, the sharp turn at SHEAD has been removed.

Route Description

The Las Vegas MST designed a primary SID and STAR which mimicked the existing northwest arrival and departure flows with modifications. The alternative design reversed the northwest arrival and departure procedures. The Las Vegas MST decided not to use the alternative design due to high terrain and climb gradients concerns.

During the Second Outreach, ZLA and L30 provided feedback indicating they would prefer the alternative design as the primary proposal. L30 provided an updated Minimum Vectoring Altitude (MVA) map. With an updated MVA map, the Las Vegas MST was able to design the LAS NW SID with runway transitions for all configurations and lower climb gradients than the SHEAD SID. This conceptual SID was designed with one en route transition that provides connectivity to the current Q-Route structure and closely follows the lateral path of the SUNST STAR. This conceptual SID is laterally segregated from SUA's to the east and the LAS NW STAR to the west.

At waypoint ST110, there is an altitude restriction to cross at or above 9,000 to ensure aircraft are at an altitude that would meet the updated MVA. The lower MVA allows ATC to vector an aircraft off the procedure if necessary. There is a crossing restriction of at or above FL210 at MYCAL to ensure aircraft are above the NATCF airspace. The restrictions and fixes are depicted in Figures 26 and 27.

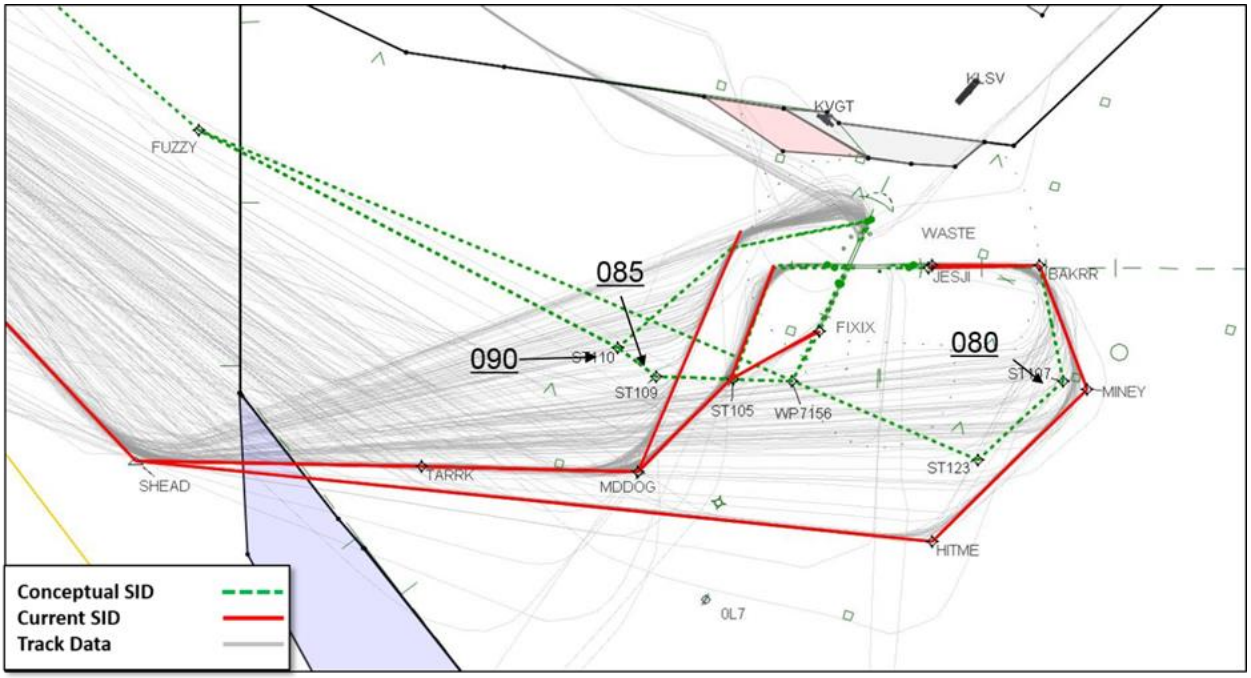

Figure 26. SHEAD SID and the LAS NW SID Terminal View

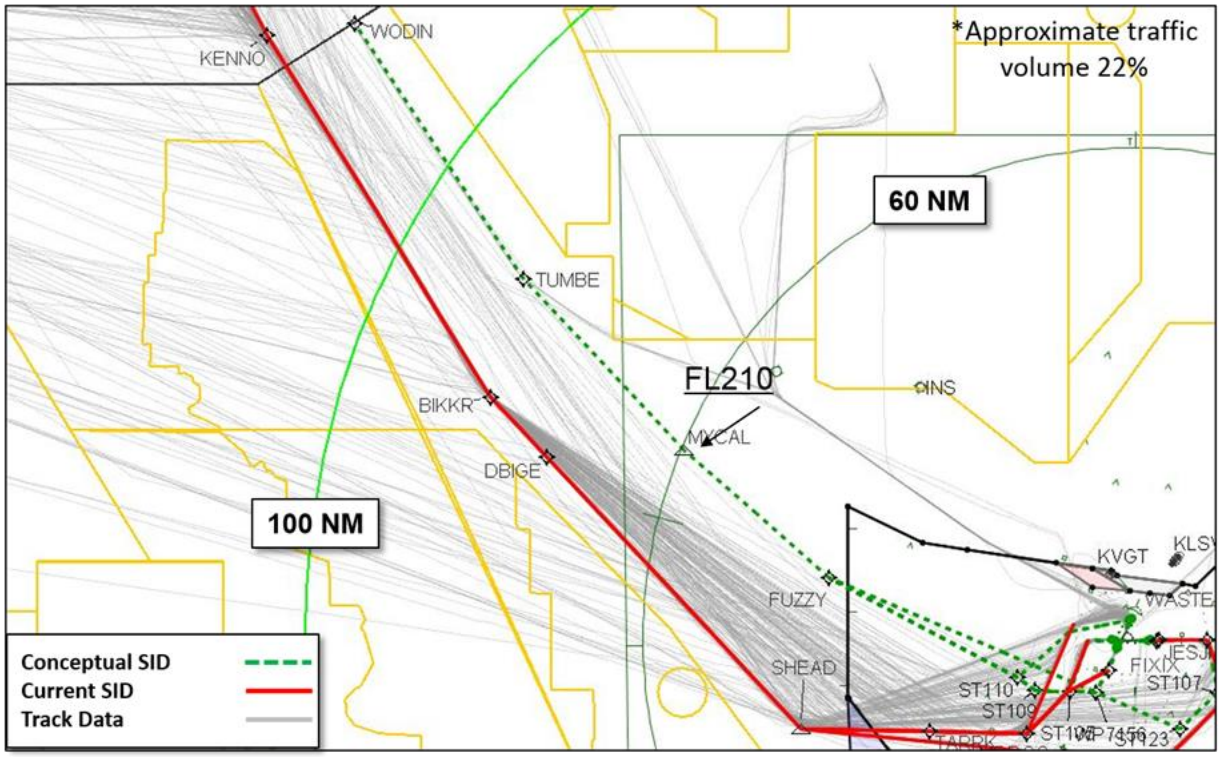

Figure 27. SHEAD SID and the LAS NW SID En Route View

Qualitative Benefits

The LAS NW SID was designed for repeatable, predictable course guidance for all configurations with connectivity to the current Q-Route structure. Safety is enhanced by optimizing the procedure and reducing task complexity, phraseology, number of pilot/controller transmissions, and readback/hearback errors.

The LAS NW SID was procedurally deconflicted from all conceptual STARs.

Quantitative Benefits

The Las Vegas MST was able to design an RNAV SID that significantly reduces the amount of lateral track miles and removes all interactions with the conceptual STARs. Since there are no interactions, the SID is designed to climb unrestricted.

By optimizing the vertical profile, the LAS NW SID reduces time and distance in level flight resulting in a reduction in fuel burn and carbon emissions. The estimated annual benefits for the LAS NW SID are shown in Table 16.

Table 16. Estimated Annual Savings for the LAS NW SID

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
LAS NW SID	578,000	$1,646,000	5,400

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.3.2.7 Summary of Potential Benefits for LAS Conceptual SIDs

As shown in Table 17, the proposed LAS SIDs are estimated to provide over $1.5 million in fuel savings annually and a reduction of 5,000 metric tons of carbon emissions.

Table 17. Estimated Annual Savings for LAS SIDs

Procedure	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
NW/SHEAD	578,000	$1,646,000	5,400
SW/BOACH	86,000	$245,000	800
SE2/PRFUM	11,000	$32,000	100
SE1/COWBY	(173,000)	($494,000)	(1,600)
NE2/TRALR	(11,000)	($31,000)	(100)
NE1/STAAV	43,000	$122,000	400
TOTAL	534,000	$1,521,000	5,000

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

4.4 Additional Design Considerations

In addition to developing conceptual STARs and SIDs, the Las Vegas MST designed RNP procedures for LAS, T-Routes to proceduralize low altitude routes, and an alternative design for the northwest corridor which segregates satellite traffic and LAS turboprops.

4.4.1 Required Navigation Performance Procedure

There are currently no RNP procedures for LAS. Industry and L30 requested RNP approaches for all configurations which mimic historical flight track data. Stakeholders requested RNP approaches which utilize Radius to Fix (RF) turns to the final approach course. Initial conceptual approaches were designed for all runways. During the Second Outreach L30 requested the Runway 07L RNP approach be deleted.

As depicted in Figure 28 LAS RNP procedures to the final approach course were designed for all configurations (25L/R, 19L/R, 07R and 01L/R). The Las Vegas MST recommends that conceptual RNP SIAPs at LAS be reviewed during the D&I phase for optimized downwind alignment and reduction in arc length.

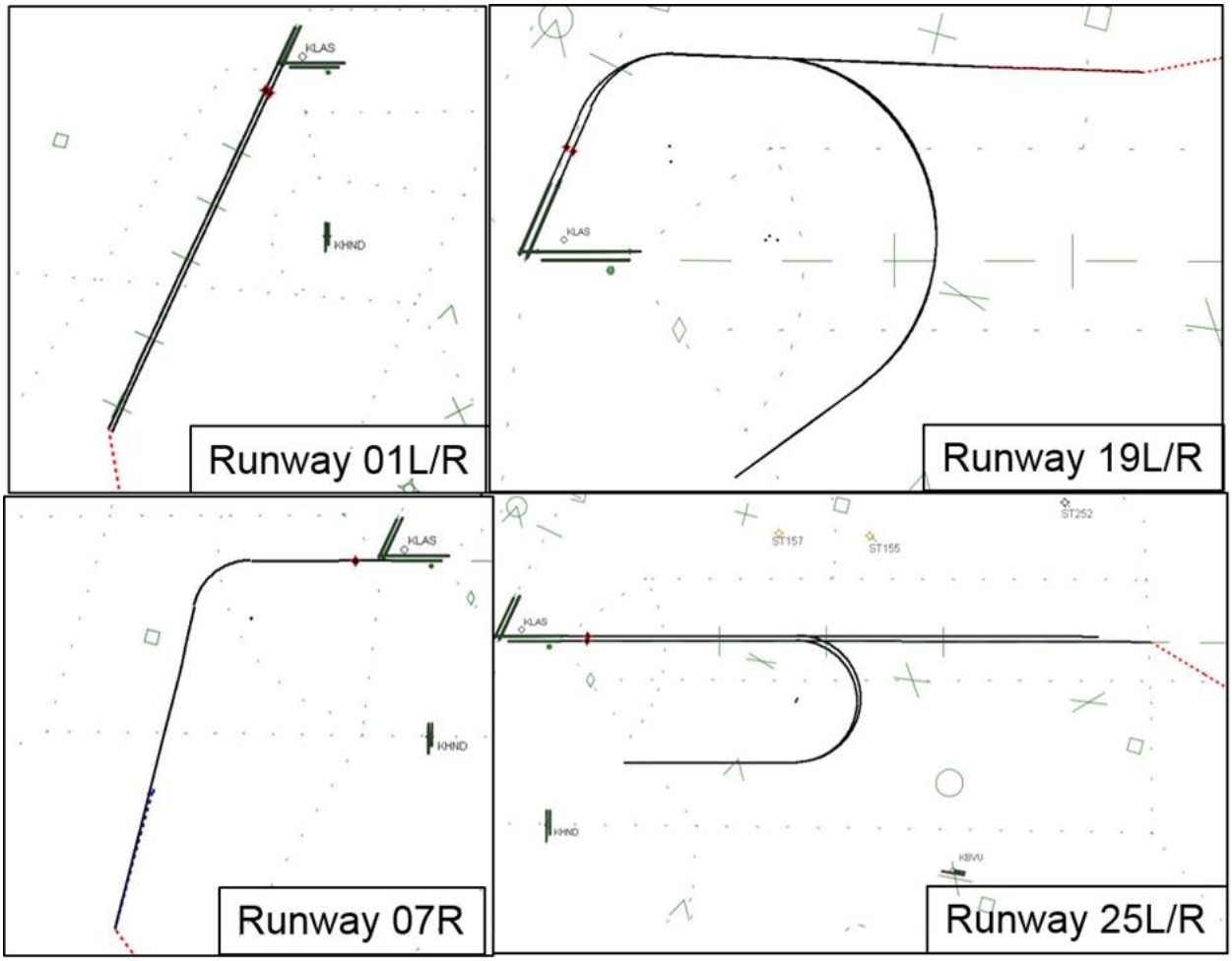

Figure 28. LAS RNP Approaches

4.4.2 Northwest Alternative Design

Issues

LAS turbojet and turboprop arrivals must share the same lateral path on the SUNST STAR. This requires ATC to separate aircraft vertically and turboprops are descended to 15,000 feet in an area that has limited surveillance coverage. This leads to an increase in task complexity.

LAS and HND turbojet arrivals utilize the SUNST STAR and require ZLA to deliver aircraft to L30 in trail. These aircraft can have significant differences in flight characteristics resulting in excessive vectors and speed assignments. This can cause flight delays and an increase in task complexity.

Solutions

The Las Vegas MST is proposing an alternative design for the northwest arrival/departure corridor with three transitions that are laterally deconflicted. The addition of the third route allows ZLA to utilize one of the routes for LAS turboprop and HND turbojet/turboprop arrivals.

The conceptual design still allows the arrival/departure flows to be reversed (departures on the east side of the corridor and arrivals on the west) as mentioned in Sections 4.3.1.5 and 4.3.2.6. The Las Vegas MST proposes that the center route be used as the offload route for LAS turboprop and HND turbojet/turboprop arrivals.

Route Description

The Las Vegas MST designed the arrival routes to be laterally segregated between the LEE Shelf and the L30 boundary (approximately 40 NM), after which the two arrival routes join. Figure 29 depicts the Northwest Alternative Design.

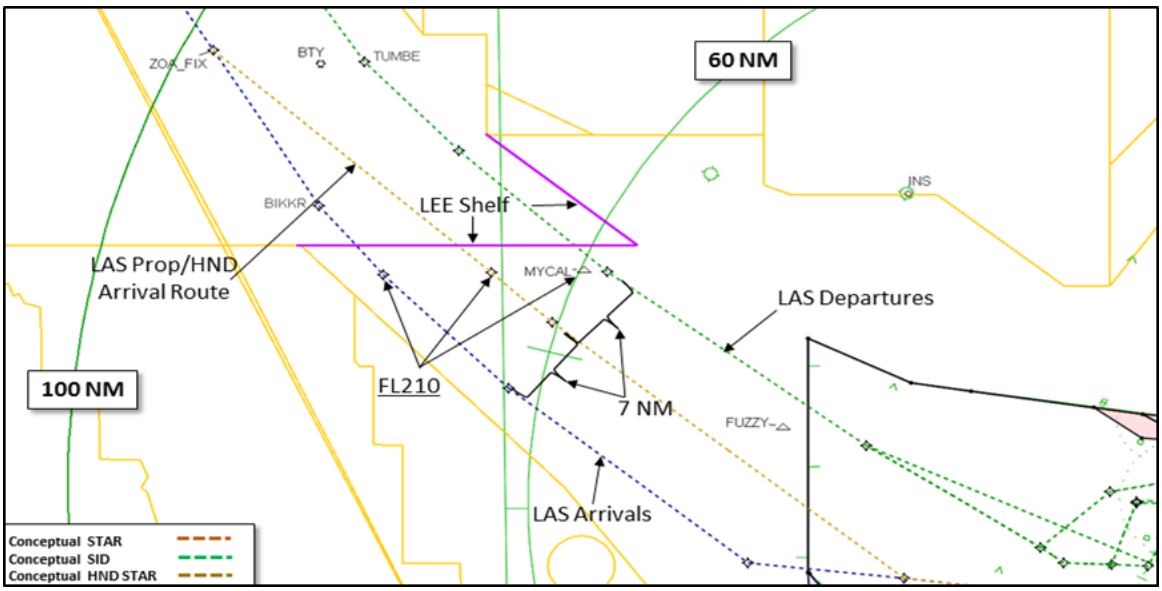

Figure 29. Northwest Alternative Design

Qualitative Benefits

This alternative design allows the LAS turbojet arrivals to descend via the conceptual OPD STAR with minimum interaction with turboprops and HND turbojets. This will reduce pilot/controller task load and complexity.

D&I Considerations

Due to time constraints, the Las Vegas MST was unable to fully explore the viability of this option. Items that need to be reviewed are: proximity to SUAs, route separation, location of holding patterns, and gaps in surveillance coverage.

4.4.3 T-Routes

Issues

L30 uses radar vectors in the absence of published routes to traverse Class B airspace. Stakeholders requested low altitude RNAV routes through Class B airspace which provide predictable, repeatable paths. ZLA identified multiple Victor airways were being filed by small props exiting L30 airspace to the southwest.

Solutions

The Las Vegas MST identified an opportunity to proceduralize routes below FL180 by utilizing low altitude RNAV routes (T-Routes) in the terminal and en route airspaces. L30 assisted the Las Vegas MST to design two T-Routes to be used east or west of LAS based on configuration and terminate in the vicinity of VGT. ZLA requested a T-Route for departure traffic destined for Southern California airports. This conceptual T-Route can be used to enter and exit the L30 airspace. Further development of T-Routes will be done during the D&I process. Figure 30 depicts the proposed LAS T-Routes.

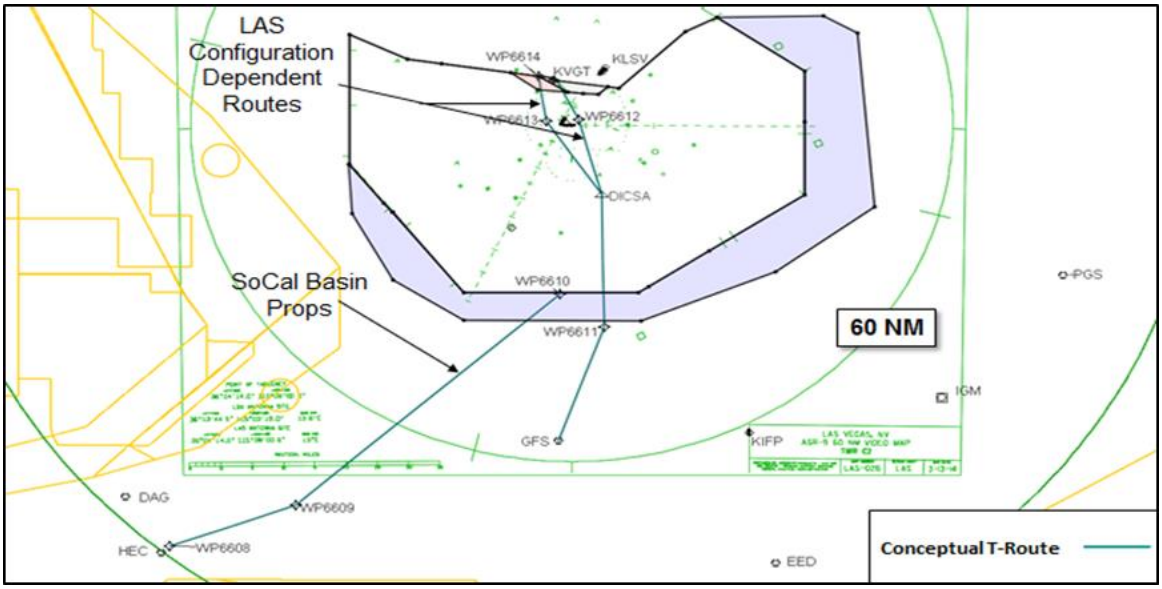

Figure 30. LAS T-Routes

4.5 Satellite Airport Operations

Stakeholders requested procedures for the Las Vegas satellite airports which provide predictable, repeatable course guidance and reduce dependencies between operations at neighboring airports. The Las Vegas MST designed conceptual STARs and SIDs for HND and VGT. The Las Vegas MST designed conceptual SIDs for LSV.

4.5.1 HND Conceptual Procedures

Issues

Stakeholders reported that due to the close proximity of HND and LAS airports, current procedures for arrivals into LAS create delays for HND departures. HND does not have a published departure procedure for Runways 35L/R. HND SIDs need to be connected with LAS SIDs in the en route environment.

HND northeast and east arrivals interact with the busiest arrival stream into LAS. Arrival procedures are inefficient and create task complexity for L30 and ZLA. The entry point into L30's airspace of the current HND northeast STAR requires coordination between ZLA Sectors 7 and 8. Multiple entry points for HND from the southeast to southwest require coordination between ZLA Sectors 6 and 8 and increases task complexity for L30.

SID Solutions

The Las Vegas MST worked extensively with National Business Aviation Association (NBAA) to design efficient Runway 17R and Runway 35L departure procedures. The Las Vegas MST created four conceptual RNAV SIDs (HND E SID, HND NE SID, HND SE SID, and HND SW-NW SID). Mountainous terrain in the vicinity of the HND airport was a primary concern in developing these procedures.

To provide common en route transitions, the HND SIDs follow conceptual LAS SIDs except the HND NE SID has a northbound transition from GEEOO to WINEN.

L30 and ZLA expressed concerns about mountainous terrain for Runway 35L departure procedures and gaps in surveillance coverage on the HND SW/NW SID.

A Diverse Vector Area (DVA) is scheduled to be published in November 2016. A DVA allows ATC to assign departure headings to Instrument Flight Rules (IFR) aircraft below the MVA.

The restrictions and fixes for the HND SIDs are depicted in Figure 31.

STAR Solutions

The Las Vegas MST worked extensively with NBAA to design efficient arrival procedures for HND. The Las Vegas MST created three conceptual RNAV STARs (HND NE STAR, HND NW STAR, and HND S STAR).

The HND NE STAR has two en route transitions that merge prior to terminal airspace and enter L30 south of the LAS Runways 25L/R extended centerline. The procedure continues to HAKID which is the initial fix for the RNAV (Global Positioning System [GPS]) B approach. The conceptual STAR is procedurally deconflicted from the LAS arrivals. The restrictions and fixes are depicted in Figure 32.

The HND NW STAR follows the LAS NW STAR through the northwest corridor and diverges at ST100. The restrictions and fixes are depicted in Figure 32.

The HND S STAR has three en route transitions and a common route into L30 airspace from the south. The procedure continues to HAKID which is the initial fix for the RNAV (GPS) B approach. The restrictions and fixes are depicted in Figure 33.

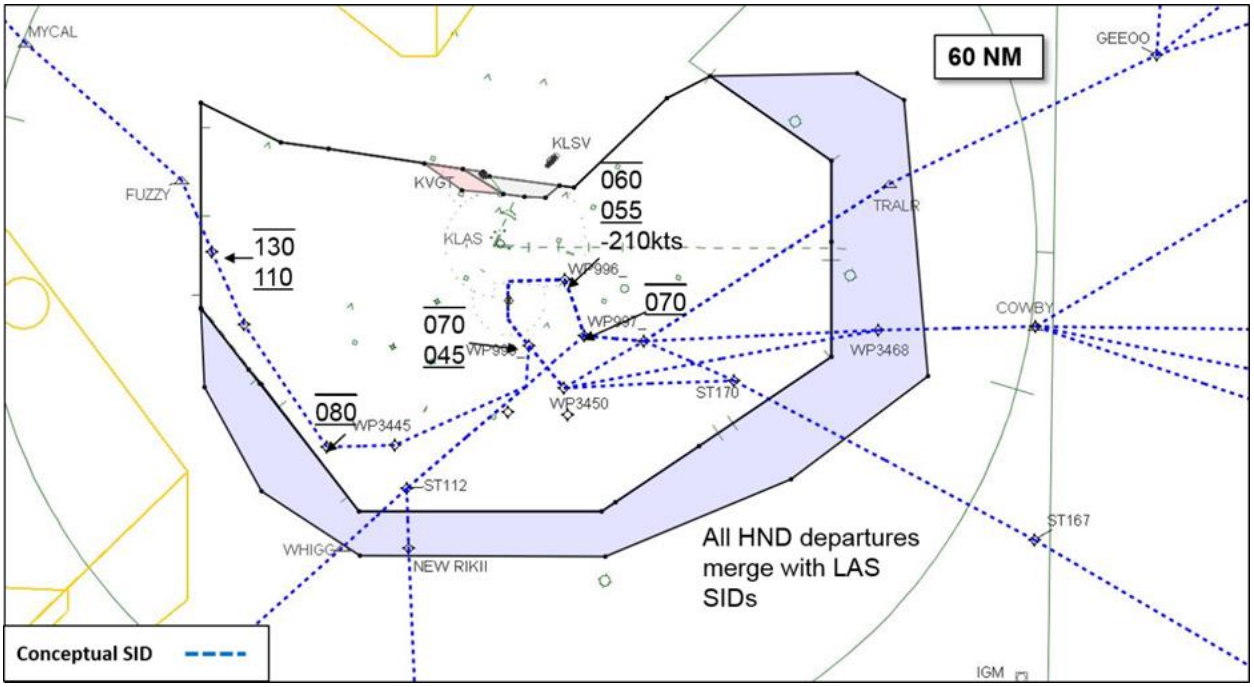

Figure 31. HND SIDs

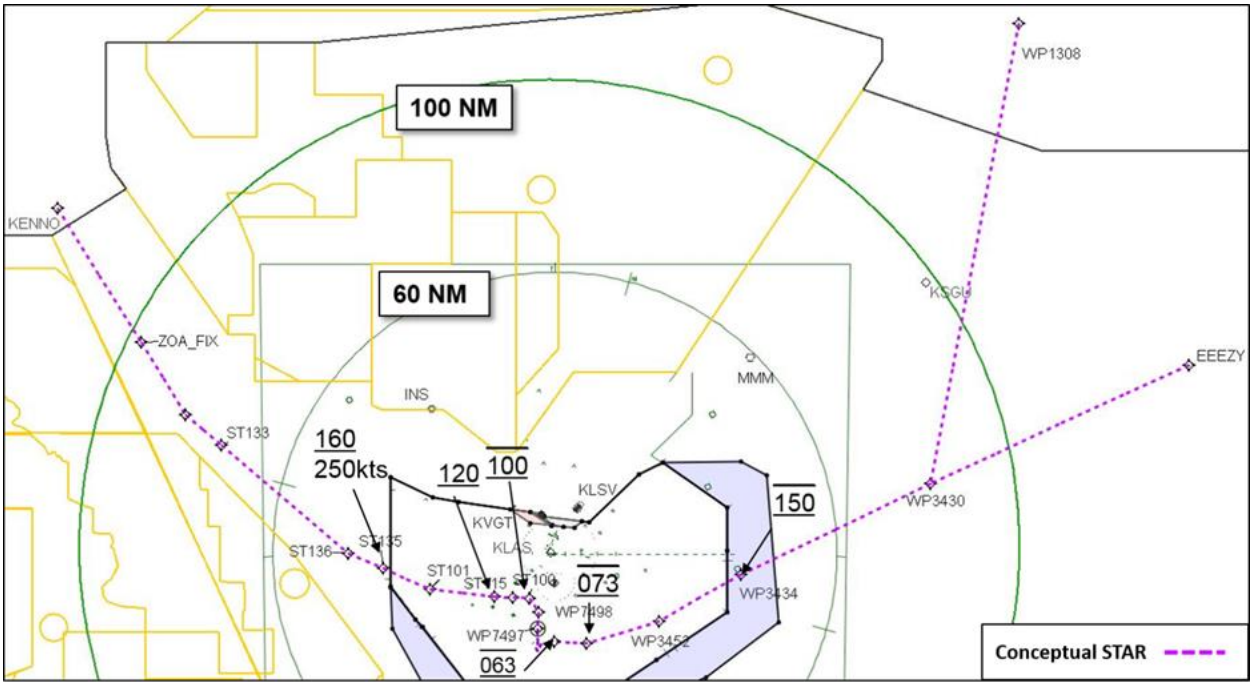

Figure 32. HND NE and NW STAR

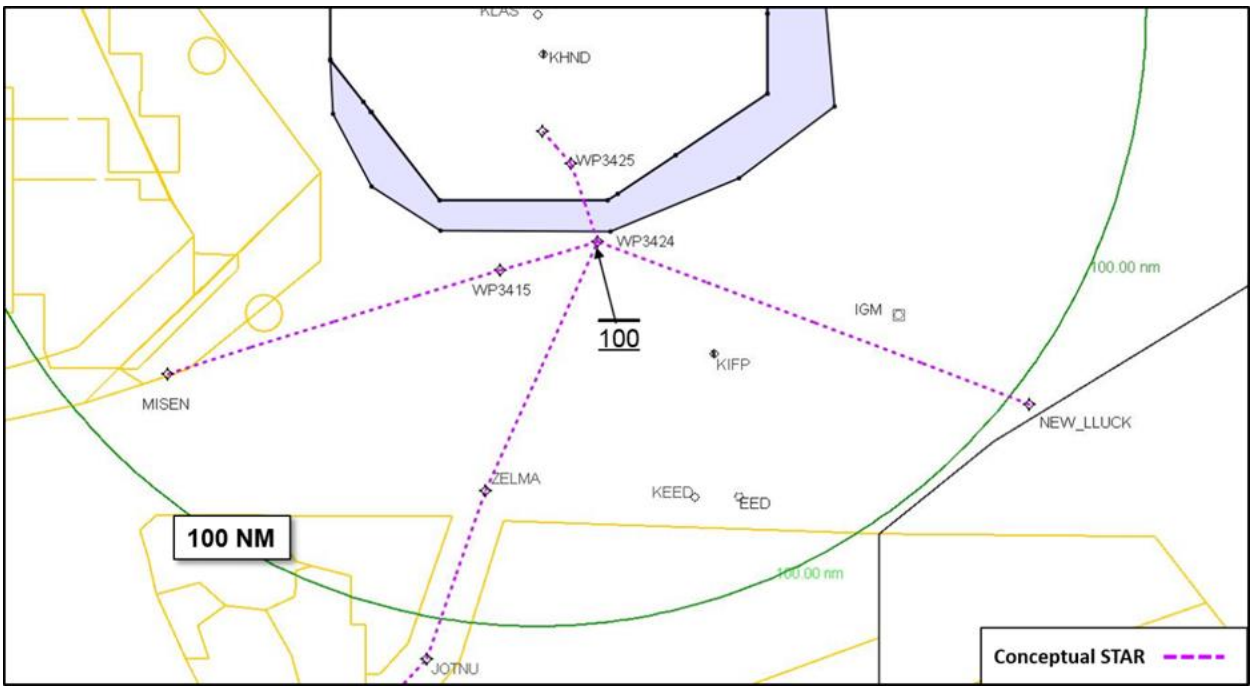

Figure 33. HND STAR

4.5.2 VGT Conceptual Procedures

Issues

VGT stakeholders identified IFR departure delays due to close proximity to LAS and LSV and inefficient departure procedures. Stakeholders requested that the current conventional procedures be replaced with more efficient PBN procedures.

SID Solutions

The Las Vegas MST worked with NBAA to design four conceptual RNAV SIDs (VGT E/SE SID, VGT NE SID, VGT NW SID, and VGT SW SID).

For improved versatility, the conceptual procedures utilize initial radar vectors. The southeast and southwest SIDs utilize identical en route transitions as the LAS SIDs. After initial departure vectors, the northeast and northwest SIDs are contained within NATCF airspace.

A DVA is scheduled to be published in November 2016. A DVA allows ATC to assign departure headings to IFR aircraft below the MVA.

The Las Vegas MST recommends NATCF assume control of departures having routes contained within LSV airspace. VGT south flow operations will need to be further explored during D&I for agreement on southbound departure procedures. Overall coordination between VGT, NATCF and L30 may be reduced with NATCF working north and northwest departure flows.

The restrictions and fixes for the VGT SIDs and STARs are depicted in Figures 34 and 35.

STAR Solutions

The Las Vegas MST worked with NBAA to design four conceptual RNAV STARs (VGT NE STAR, VGT NW STAR, VGT SE STAR, and VGT SW STAR).

The VGT NW and NE STARs transition from the en route structure through NATCF airspace bypassing L30. The VGT SE and SW STARs are designed to traverse L30 airspace and will exit northwest of LAS with connectivity to the GPS RWY12R approach.

The restrictions and fixes for the VGT SIDs and STARs are depicted in Figures 34 and 35.

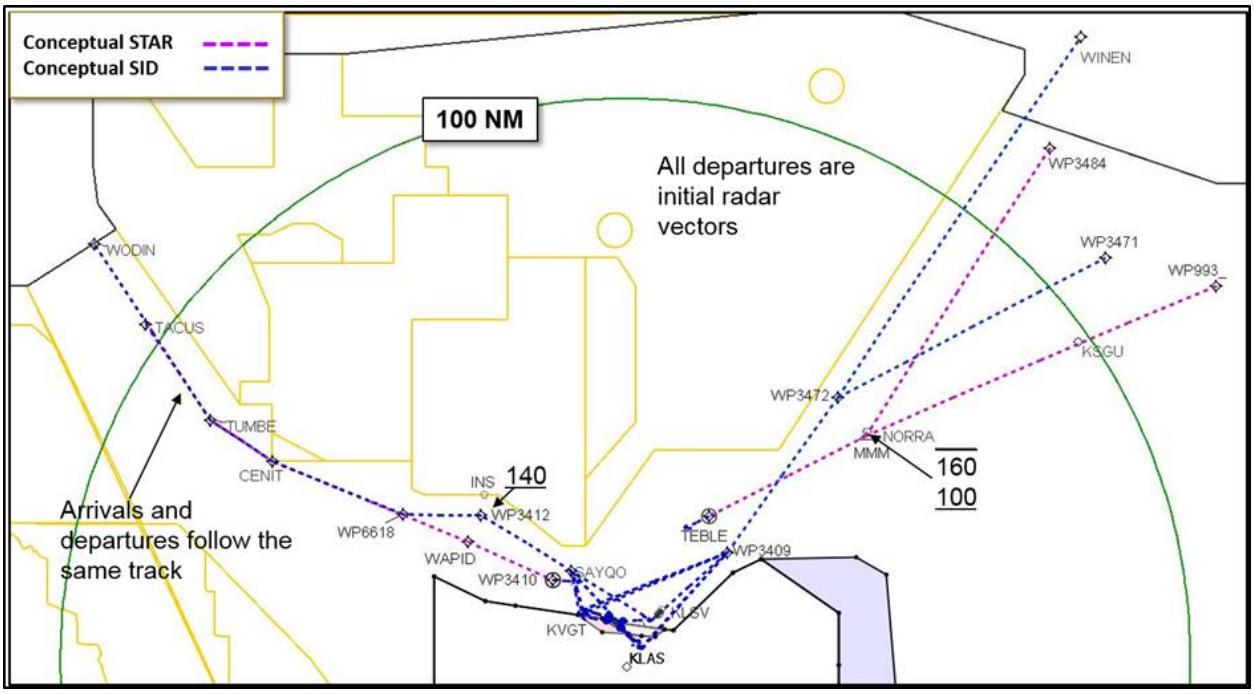

Figure 34. VGT North SIDs and STARs

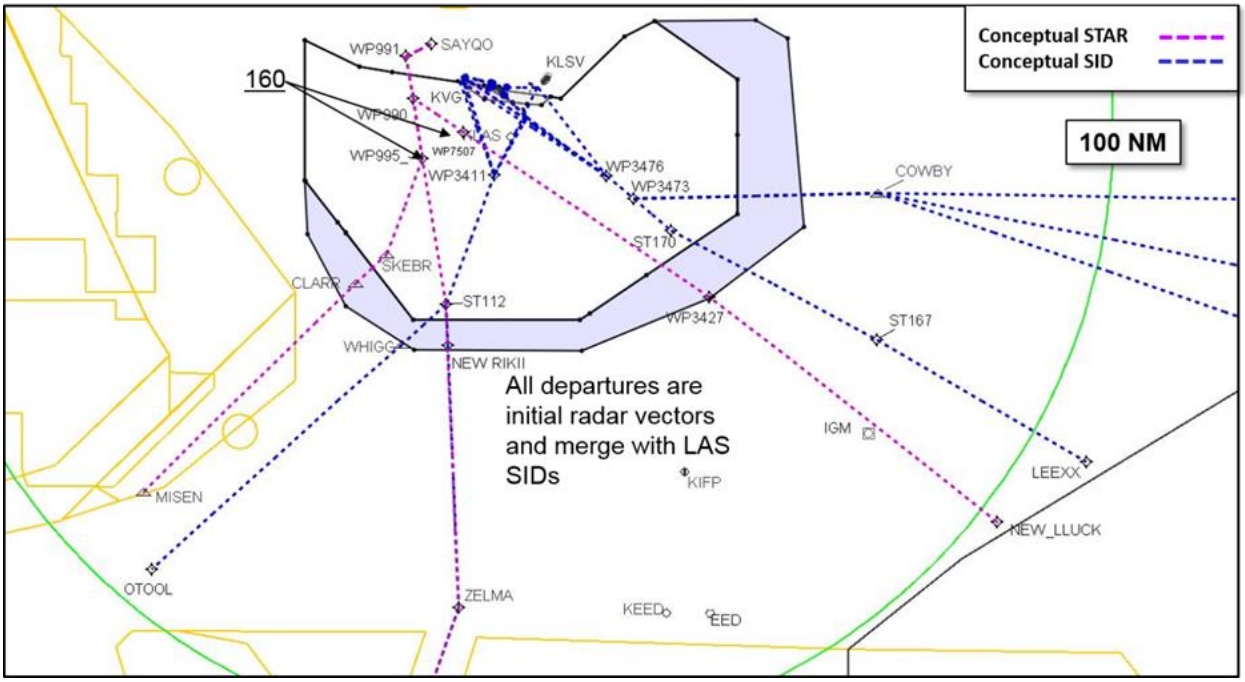

Figure 35. VGT South SIDs and STARs

4.5.3 LSV Conceptual Procedures

Issues

LSV, LAS, and VGT are within a 10 NM radius which creates interactions and delays for LSV operations. There is no published Runway 21 SID for southbound departures. All southbound departures are vectored and must be released for departure by L30.

SID Solutions

The Las Vegas MST designed four LSV RNAV SIDs.[8] (LSV E/SE SID, LSV NE SID, LSV NW SID, and LSV SW SID). For improved versatility the conceptual procedures utilize initial radar vectors. Southbound departures entering L30's airspace will be addressed during D&I. The Las Vegas MST recommends that NATCF and L30 consider addressing airspace delegation. Figure 36 depicts the LSV NW SID and LSV NE SID. Figure 37 depicts LSV SW SID and LSV E/SE SID.

[8] The LSV conceptual SID design are informational only and provided to DOD for consideration.

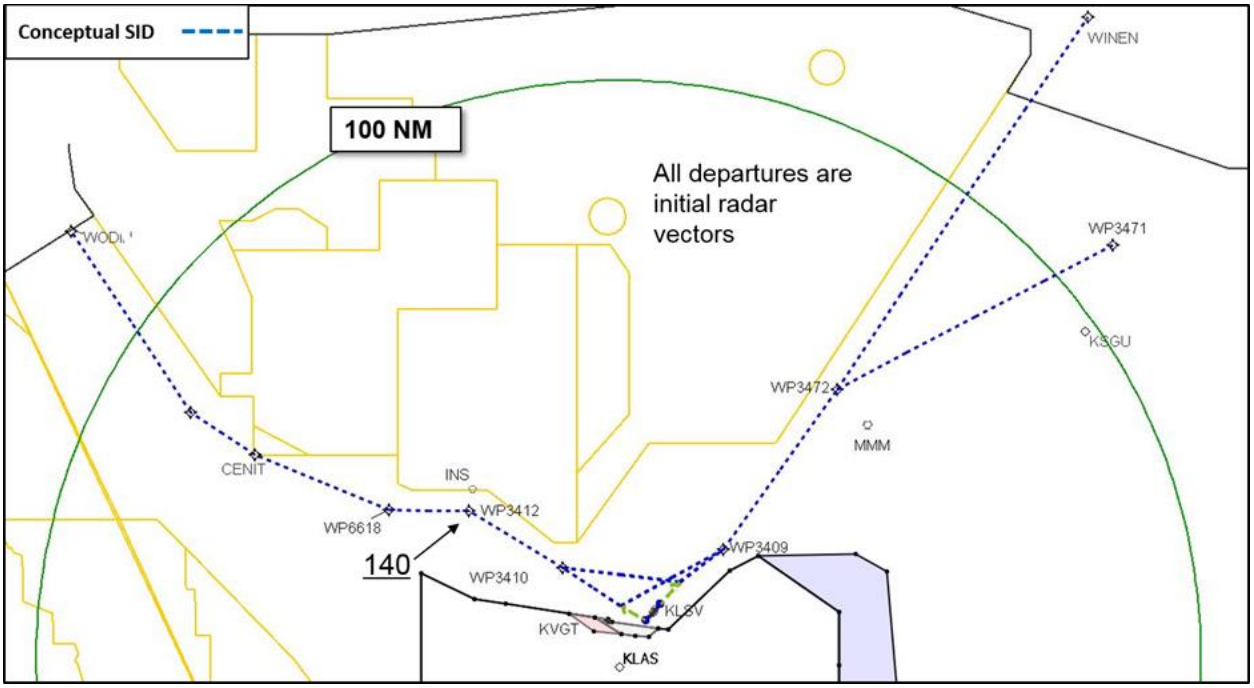

Figure 36. LSV NW SID and LSV NE SID

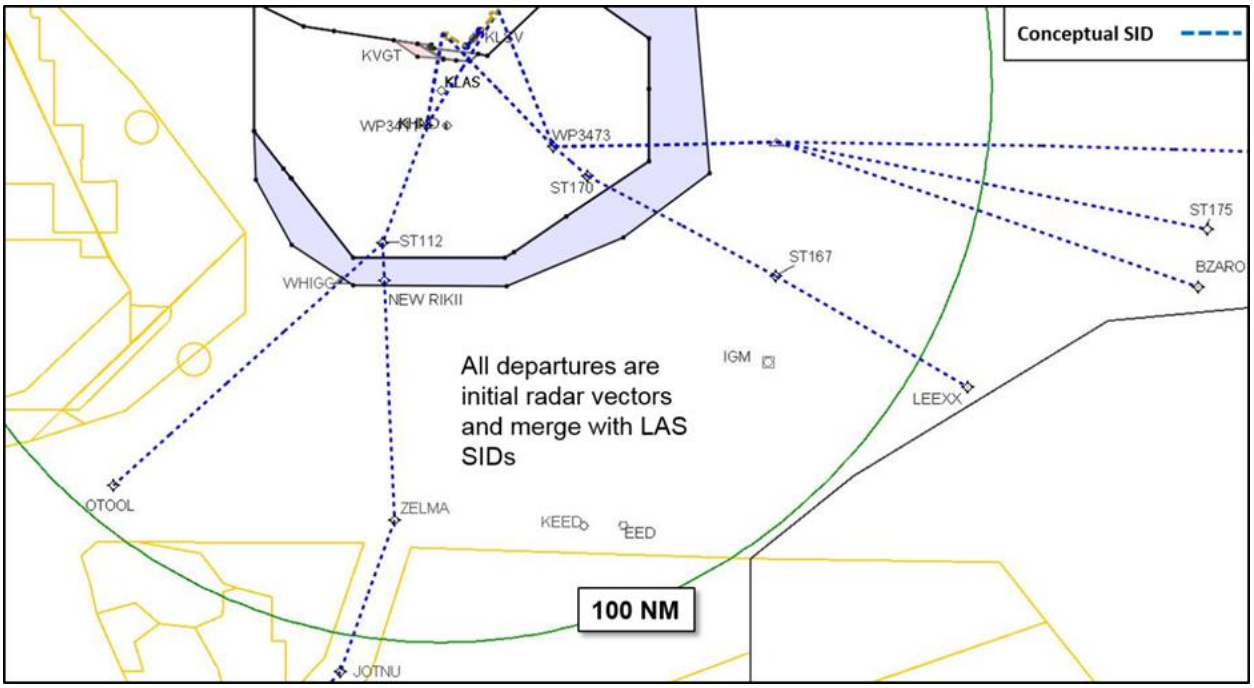

Figure 37. LSV SW SID and LSV E/E SID

4.6 Stakeholder Concerns

Stakeholders expressed 18 areas of concern to the Las Vegas MST of which 16 were addressed. Issues related to LAS operations focused on the absence of STAR and SID runway transitions for all configurations and inefficiencies related to the TYSSN STAR. Industry expressed concerns about aircraft performance and high climb gradients. The Las Vegas MST designed conceptual SIDs and STARs with runway transitions for all configurations. Conceptual SID climb gradients were decreased where possible.

Satellite airport users identified issues which included a lack of a published SID from Runway 35L at HND and conflicting departure and arrival flows between LAS and satellite airports resulting in departure delays. The LAS MST designed conceptual satellite SIDs that merged with LAS SIDs or were routed through Nellis NATCF airspace. For procedures routed through Nellis NATCF airspace, the LAS MST anticipates reduced delays relating to LAS operations.

4.7 Out of Scope Issues Submitted by both ATC and Stakeholders

Issues were identified that were beyond the scope of the Las Vegas MST and have been recorded for further consideration outside of the Metroplex process. The Las Vegas MST decided 25 issues were out of scope. They have been recorded in the Las Vegas MST Issues Matrix.

Funding and equipment requests such as adding sectors, equipment, or personnel are out of Metroplex scope due to long range funding. While new radar systems would improve much needed surveillance coverage in the Las Vegas Metroplex area, the cost of new systems takes long term planning and funding which is outside of the Metroplex scope.

Modifying the Las Vegas airport surface operations or implementing new airport infrastructure is outside of Metroplex environmental requirements. Issues such as Class B airspace modifications requires rule making actions that exceed Metroplex timelines.

The Las Vegas MST recommends the facilities amend existing Letters of Agreement (LOAs), resolve automation issues, and implement changes to video maps as required. Automated Information Transfer (AIT) procedures should be worked as soon as possible by affected parties.

4.8 D&I Issues

The Las Vegas MST identified and characterized a range of issues and developed a number of conceptual solutions; however, some require additional coordination and input that could not be addressed within the time constraints of the MST process. The Las Vegas MST deferred 23 issues to be further explored during the D&I process.

En route and terminal sectorization/airspace modifications will need to be assessed to ensure final designs are contained in necessary sectors. In conjunction with sectorization, incorporation of holding pattern and requirements for final procedures will need a thorough review in both terminal and en route environments. Conventional procedures may require amendments.

Synchronization of transitions from STARs to SIAPs to ensure continuity is required. The D&I team should consider actions to amend or install new missed approach procedures. Playbook and Severe Weather Avoidance Program (SWAP) routes should be addressed. Route changes for extreme weather and other events along with improved TBFM initiatives should be incorporated.

Metroplex Inter- and Intra-facility issues such as LOAs and Standard Operating Procedure (SOP) changes and identified Aviation Safety Information Analysis and Sharing (ASIAS) safety concerns should be addressed in the D&I process.

As part of the D&I phase, the Las Vegas Metroplex facilities should coordinate with adjacent facilities that will provide input to procedure designs. The Las Vegas MST recommends adjacent Air Route Traffic Control Centers (ARTCC) be included to ensure connectivity.

Las Vegas MST conceptual procedures were designed with connectivity to the Phoenix and Southern California Metroplex projects and may require modification based on the status of those projects.

4.9 Community Outreach

Increased FAA, community, and political sensitivity has created the need for early coordination and communication to ensure procedural development considers community concerns. Process development is ongoing to ensure the appropriate activity is in place to meet this goal. The Las Vegas project will be the first Metroplex project to embrace this activity from inception to implementation if the decision is made to move to the D&I phase of the metroplex process.

The Metroplex Program Office met with the CCDOA Director to establish a collaborative process that engages the airport authority as a liaison for public concerns. The initial process included a request that the CCDOA fill out an issues Matrix to identify historical concerns.

The CCDOA and the FAA ADO were invited to the three outreach sessions the Las Vegas MST conducted with Industry Stakeholders to ensure transparency. Several meetings were held to compare historical concerns with conceptual designs to allow the Las Vegas MST to consider mitigations, if necessary. The original data is recorded in the Las Vegas Issues Matrix and will be briefed to the Las Vegas D&I team, if one is established.

4.10 Aviation Safety Information Analysis and Sharing (ASIAS)

ASIAS is a collaborative industry and government initiative to study and advance aviation safety. ASIAS uses public, FAA, and protected data sources to generate safety metrics. FAA data such as radar track data from the NOP, real-time aircraft tracking provided by TFMS, and fused radar trajectories of the TT are used to generate safety metrics such as Traffic Alert and Collision Avoidance System (TCAS) Resolution Advisory (RA) events. Protected data such as the voluntary pilot reports from the Aviation Safety Action Program (ASAP), digital flight data from Flight Operation Quality Assurance (FOQA), and Air Traffic Safety Action Program (ATSAP) reports are used to generate safety metrics such as Missed Crossing Restrictions (MCRs), Unstable Approaches (UAs), and Terrain Awareness and Warning System (TAWS) alerts.

Safety events identified by the data can benefit from operational knowledge to help interpret the results. ASIAS is available to provide additional safety analysis or provide clarification of the data to the Las Vegas MST or to the D&I Team during later phases of the metroplex process.

For the airports in the Las Vegas Metroplex, ASIAS used one year of data (from March 1, 2014 to February 28, 2015) to evaluate safety events in the current environment. Safety events were analyzed for LAS, HND, and VGT airports. The following safety information was provided to the Las Vegas MST for their consideration when developing conceptual airspace and procedures for the Las Vegas Metroplex:

- LAS airport has a low rate of TCAS RA events when compared to the Core 30 airports, however, there appears to be two locations where there is a concentration of TCAS RA events or hotspots.

- The first hotspot is in Configuration 1 and occurs approximately four to five NM from the arrival threshold for Runway 19L/R. Figure 38 depicts the arrival and departure tracks and TCAS RA events when LAS is operating in Configuration 1. The yellow circle highlights the concentration of events between:
    - LAS air carrier arrivals and departures and
    - LAS air carrier arrivals and satellite/general aviation traffic.

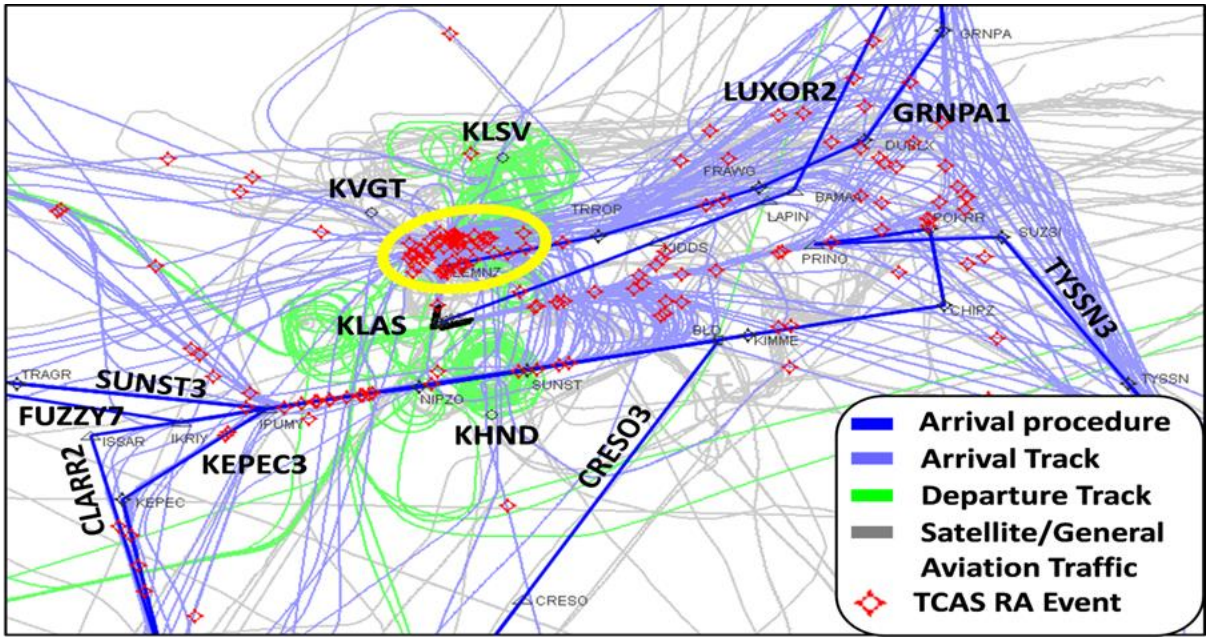

Figure 38. LAS Configuration 1 TCAS RA Arrival Hotspot

- The second hotspot occurs when LAS is using Configuration 3. The events occur between:
    - LAS air carrier arrivals and departures and
    - LAS air carrier arrival and satellite/general aviation traffic. The hotspot for this configuration is approximately 3 to 10 NM from the arrival threshold for Runway 1L/R and is depicted in Figure 39. As with Figure 40, the hotspot is highlighted using a yellow oval.

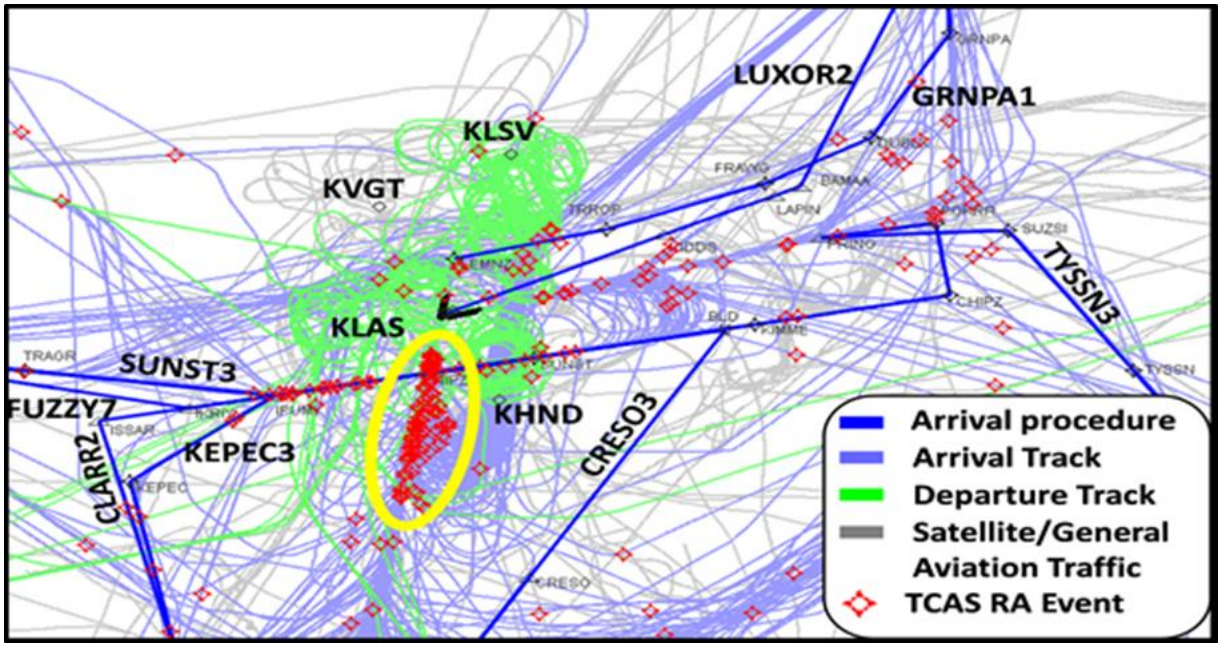

Figure 39. LAS Configuration 3 TCAS RA Arrival Hotspot

HND airport has an above average rate of TCAS RA events when compared to the Core 30 airports, and one hotspot for TCAS RA events between HND's arrivals and departures. The hotspot appears to be located approximately two to three NM from the arrival threshold for Runway 35L and is depicted in Figure 40 with a yellow circle highlighting the TCAS RA hotspot

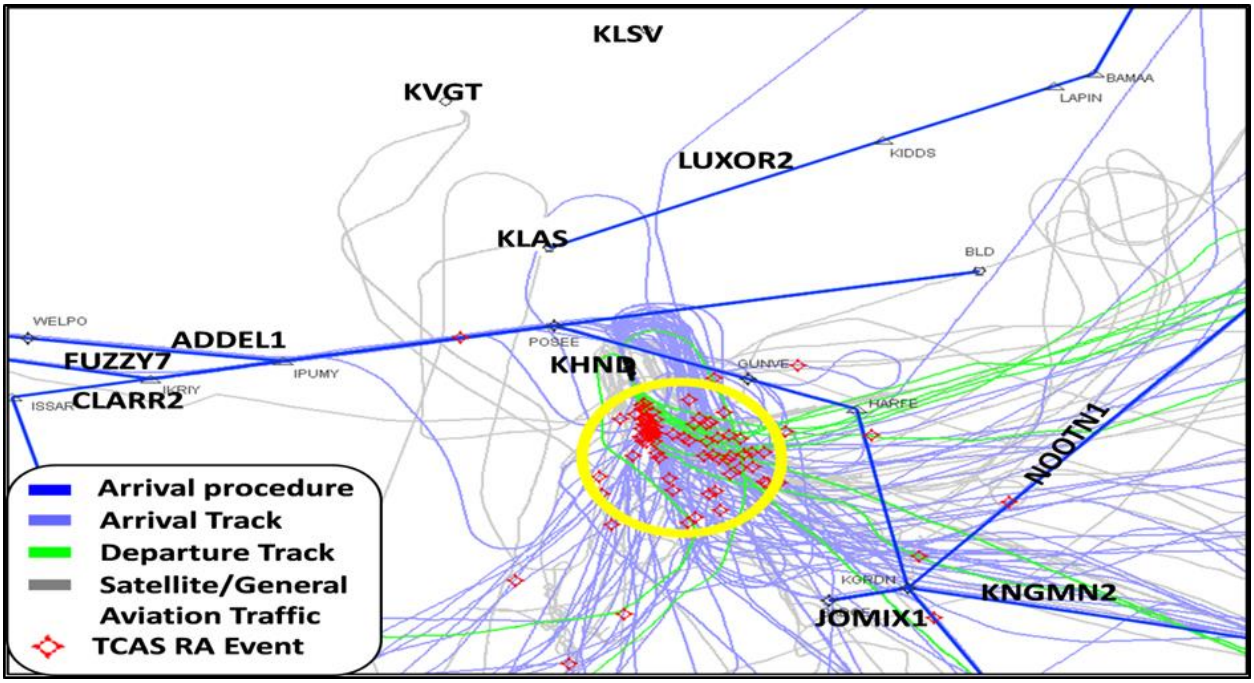

Figure 40. HND TCAS RA Arrival Hotspot

- LAS has an above average reported rate of Missed Crossing Restrictions for arrival and departure flows when compared to the Core 30 airports.
    - KEPEC3, GRNPA1, and TYSSN3 are the most frequently cited procedures for arrival flows. SHEAD8 and TRALR5 are most frequently cited procedures for departure flows.
- LAS has an above average rate of UAs below 500 feet when compared to the Core 30 airports. High rate of descent and high speed are the primary drivers for UAs below 500 feet. The UA rate at LAS appears to be seasonal which is consistent with results from other airports throughout the NAS.
- LAS has above average rate of TAWS events when compared to the Core 30 airports. Most events occur in the area of hills and mountains. Figure 41 shows the TAWS event for LAS.

All ASIAS concerns should be considered during D&I.

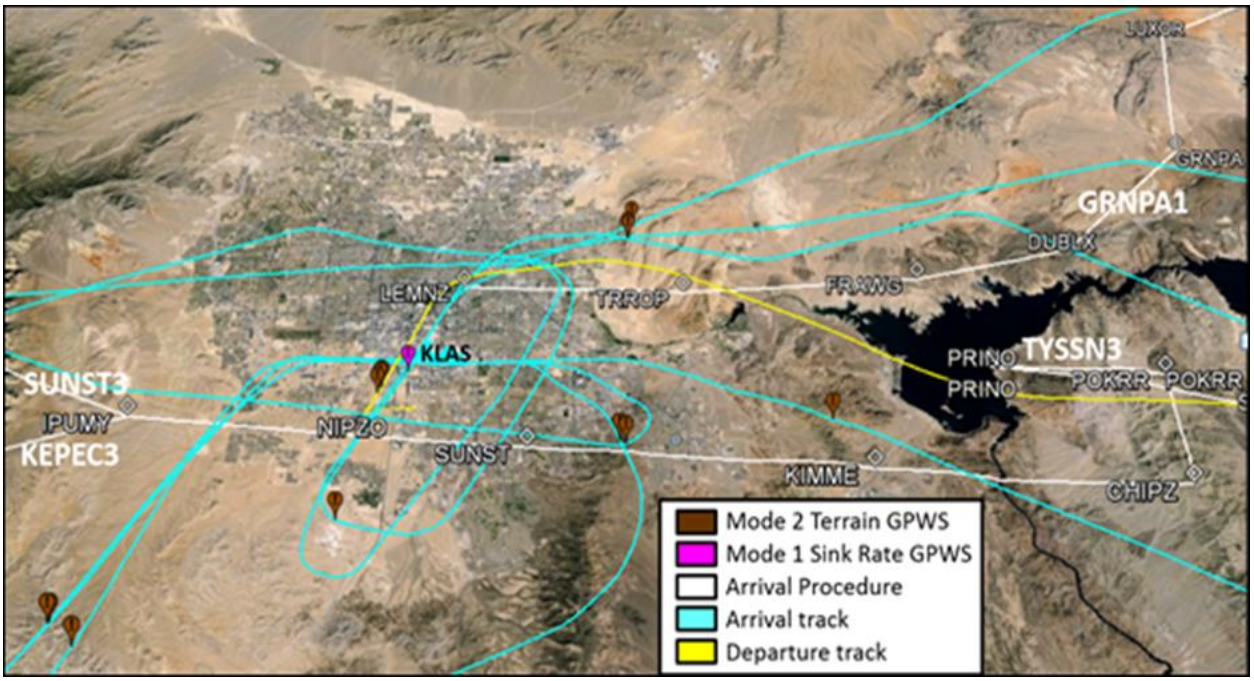

Figure 41. TAWS Events for LAS

5 Qualitative Benefits

5.1 Near-Term Impacts

The benefits of the PBN procedures proposed by the Las Vegas MST include the following:

- Reduced phraseology, fewer transmissions, and pilot workload:
    - Reduced phraseology due to PBN will reduce the number of transmissions needed to accomplish required restrictions by combining multiple clearances into a single

transmission. Prior studies have demonstrated transmission reductions on the order of 18% to 34% with 85% RNAV equipage,[9] and the Las Vegas MST believes it is reasonable to expect a similar level of savings.

  - Fewer transmissions translate into less frequency congestion which could potentially reduce readback/hearback errors.
  - The consolidation of clearances associated with an RNAV procedure reduces pilot workload, which allows for more "heads-up" time and allows the crew to focus on high-workload situations.

- Repeatable, predictable flight paths and accurate fuel planning:
  - The introduction of PBN ensures lateral flight path accuracy. The predictable flight paths help assure procedurally segregated traffic flows and allow airlines to more accurately plan for a consistent flight path.
  - Industry can more accurately predict the amount of fuel required for a procedure.
- Enhanced lateral and vertical flight paths:
  - Optimized climbs and descents and shorter lateral paths reduce the number and length of level segments and total distance flown, thereby reducing fuel burn and carbon emissions.
  - Altitude windows can vertically separate traffic flows and allow for industry-standard glide paths.

5.2 Long-Term Impacts for Industry

Implementation of the conceptual procedures will have long term effects for industry.

- Flight planning

  Metroplex conceptual procedures will result in reduced mileage and fuel burn in the long-term, particularly as more metroplexes are optimized. In the near-term, more direct paths that are not dependent on ground-based navigational aids and optimized flight profiles will lead to reduced fuel burn only within an optimized metroplex. Reduced fuel loading will also allow for a reduction in cost to carry.

- Timetable

  Shortened, more efficient routes will necessitate timetable adjustments as more metroplexes are optimized. This will potentially benefit crew scheduling, connecting information, time on gates, ramp scheduling, etc.

6 Quantitative Benefits

The quantified benefits of the Las Vegas MST recommendations are categorized into annual fuel savings in dollars, annual fuel savings in gallons, and annual carbon emissions reductions in metric tons. The primary benefit drivers are improved vertical profiles and reduced miles flown.

[9] Sprong, K., et al., June 2006, "Benefits Estimation of RNAV SIDs and STARs at Atlanta," F083-B06-020, (briefing), The MITRE Corporation, McLean, VA.

Benefits from conceptual arrival procedures came from:

- RNAV STARs with OPDs
- More efficient lateral paths created by adjusting terminal entry points and removing doglegs
- Removal of unused en route transitions and development of runway transitions

Benefits from conceptual departure procedures came from:

- Combined RNAV off-the-ground procedures and radar vector procedures that join RNAV routes
- Departure procedures designed to facilitate unrestricted climbs by removing or mitigating existing level segments
- Procedurally segregated SIDs and STARs

Table 18 breaks down the benefits for Las Vegas. The total potential annual fuel savings is estimated at $7,538,000. These numbers were estimated by comparing the flight trajectory of the existing traffic to proposed PBN procedures, primarily driven by lateral track miles and vertical profiles. The benefits analysis assumes aircraft will fly the specific lateral and vertical RNAV procedures. It is fully expected that ATC will continue to offer shorter routings and remove climb restrictions, when feasible, further increasing operator benefits.

Table 18. Summary of Benefits

	Estimated Annual Savings*		
	Fuel (gallons)	Fuel ($)	Carbon (metric tons)
Arrivals	**2,111,000**	**$6,017,000**	**19,800**
Departures	**534,000**	**$1,521,000**	**5,000**
TOTAL	**2,645,000**	**$7,538,000**	**24,800**

* Fuel Savings rounded to the nearest thousand, carbon savings rounded to the nearest hundred

Appendix A PBN Toolbox

Sample PBN Toolbox Options
Add an arrival route
Add a departure route
Extend departure routes
Build in procedural separation between routes
Reduce route conflicts between airports
Change airspace to accommodate a new runway
Add a parallel arrival route (to a new runway)
Split a departure fix that serves more than one jet airway
Increase use of 3 NM separation
Increase use of terminal separation rules
Static realignment or reassignment of airspace
Adaptive realignment or reassignment of airspace
Improve sector boundaries (sector split, boundary move, new area of specialization)
Shift aircraft routing (Avoiding re-routes, shorter routes)
Eliminate altitude restrictions
Provide more efficient holding (design, usage and management)
Add surveillance coverage
Add en route access points or other waypoint changes (NRS)
Add en route routes
Reduce restrictions due to SUA
Enhance TBFM initiatives